

THE BRITISH SOCIETY FOR THE PROMOTION
OF VEGETABLE RESEARCH

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Third
Annual Report
1952

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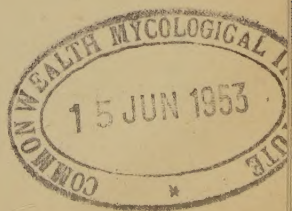
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NATIONAL VEGETABLE RESEARCH
STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 322

1953



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THE CONSTITUTION OF THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September, 1949, as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research,' with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Ministry of Agriculture and Fisheries. At the outset the Society depends for its funds on grants from this Ministry, except that if any stations are established or work is conducted in Scotland, grants will be receivable also from the Scottish Agricultural Advisory Council. Both Agricultural Departments are advised by the Agricultural Research Council (A.R.C.) who have the scientific oversight of the work and staff.

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Minister of Agriculture and Fisheries :

- Professor G. E. BLACKMAN, M.A., Department of Agriculture, University of Oxford. (Until 27/9/52)
- Professor K. MATHER, Ph.D., D.Sc., F.R.S., Department of Genetics, The University, Edgbaston, Birmingham, 15. (From 28/9/52)
- Sir WILLIAM G. OGG, M.A., Ph.D., LL.D., Rothamsted Experimental Station, Harpenden, Herts. (Until 27/9/52)
- Professor T. G. B. OSBORN, M.A., D.Sc., Department of Botany, University of Oxford. (From 28/9/52)
- Sir EDWARD SALISBURY, C.B.E., D.Sc., LL.D., F.R.S., F.L.S., V.M.H., Royal Botanic Gardens, Kew, Surrey.
- H. V. TAYLOR, Esq., C.B.E., D.Sc., A.R.C.S., V.M.H., Preston Grange, Ganwick, Potters Bar, Middlesex.

Appointed by the Secretary of State for Scotland :

- R. L. SCARLETT, Esq., O.B.E., C.D.A., Sweethope, Musselburgh, Midlothian.

Appointed by the Department of Scientific and Industrial Research :

- R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, East Malling, Kent.

Appointed by the University of London :

- Professor J. W. MUNRO, C.B.E., M.A., D.Sc., Department of Zoology and Applied Entomology, Imperial College of Science and Technology, South Kensington, London, S.W.7.

Appointed by the University of Reading :

- Professor R. H. STOUGHTON, D.Sc., A.R.C.S., Department of Horticulture, The University, Reading.

Appointed by the University of Cambridge :

- J. BARKER, Esq., M.A., Ph.D., F.R.S., The Botany School, Cambridge. (From 20/5/52)
- Professor F. T. BROOKS, C.B.E., M.A., LL.D., F.R.S., F.L.S. (Chairman), The Botany School, Cambridge. (Died 11/3/52)

Appointed by the University of Bristol :

- Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.S., F.R.I.C., V.M.H., The Research Station, Long Ashton, Bristol.

Appointed by the University of Edinburgh :

- ALEXANDER NELSON, Esq., Ph.D., D.Sc., University Department of Botany, at Royal Botanic Garden, Edinburgh, 4. (From 28/9/52)
- Professor S. J. WATSON, D.Sc., F.R.I.C., F.R.S.E., 57 Braid Avenue, Edinburgh, 10. (Until 27/9/52)

Appointed by the Royal Society :

- Professor W. BROWN, M.A., D.Sc., F.R.S., 93 Church Road, Hanwell, London, W.7.

Appointed by the John Innes Horticultural Institution :

C. D. DARLINGTON, Esq., D.Sc., F.R.S., Bayfordbury, Herts.

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G. W. GILES, Esq., O.B.E., F.R.H.S., Drayton House, Gordon Street, London, W.C.1.

Appointed by the Seed Trade Association of the United Kingdom :

A. L. DEAL, Esq., c/o W. W. Johnson & Son Ltd., Boston, Lincs.

The Executive Committee

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Watercress Advisory Sub-Committee

Professor W. BROWN

Dr. H. V. TAYLOR

*Co-opted Members***Agricultural Research Council :**

G. G. SAMUEL, Esq., M.Sc., 15 Regent Street, London, S.W.1.

National Farmers' Union :

J. BIGGS, Esq., 'Qumari,' Billington Lane, Sutton Scotney, Winchester, Hants.
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C. H. SANSOM, Esq. (Chairman), Croxley Hall Farm, Rickmansworth, Herts.

National Agricultural Advisory Service :

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J. O. JONES, Esq., M.Sc., F.R.I.C., 'Woodthorne,' Wolverhampton, Staffs.

W. E. H. HODSON, Esq., A.R.C.S., D.I.C., Provincial Entomologist, Chiltern
Court, Caversham, Reading, Berks.

C. H. OLDHAM, Esq., N.D.H., Provincial Horticultural Advisor, The George,
Winchester, Hants.

F. W. SHEPHERD, Esq., N.D.H., Rosewarne Experimental Horticulture
Station, Camborne, Cornwall.

STAFF

Director :

JAMES PHILP, B.Sc. (Glas.), Ph.D. (Lond.), F.L.S.

- Plant Breeding :** J. C. HAIGH, B.Sc., Ph.D. (Lond.), A.R.C.S., A.I.C.T.A.
 G. D. SULLIVAN, B.Sc. (Wales). (Resigned 31/8/52)
 H. HOLLAND, B.Sc. (Wales). (Appointed 15/7/52)
 L. E. WATTS, B.Sc. (Wales). (Appointed 15/7/52)
 E. M. WATSON, N.D.A., C.D.A. (Glas.). (Appointed 5/8/52)
Assistant : D. D. CLARKE. (Appointed 14/1/52)
- Pathology :** W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.
 (Appointed 1/4/52)
 D. M. SPENCER, B.Sc. (Wales). (Resigned 31/1/52)
 J. A. TOMLINSON, B.Sc., Ph.D. (Birm.). (Appointed 16/6/52)
Assistant : Miss J. THORPE. (Appointed 15/9/52)
- Entomology :** D. W. WRIGHT, M.A. (Cantab.).
 J. A. DUNN, M.Sc. (Dunelm).
 G. A. WHEATLEY, B.Sc. (Dunelm).
 J. Y. RITCHIE, B.Sc. (Glas.). (Appointed 18/8/52)
Assistants : H. I. SMITH.
 Miss V. M. HAWKER. (Appointed 22/9/52)
 R. E. MONRO. (Temporarily from 26/11/51 to 30/9/52)
- Physiology :** A. H. PARKINSON, B.Sc. (Reading), M.S. (Cornell), Ph.D. (Lond.). (Resigned 15/3/52)
- Irrigation :** E. J. WINTER, M.C., M.Sc. (Bristol).
Assistants : Miss G. A. PURDY.
 B. G. HUNT. (Appointed 2/9/52)
- Chemistry :** R. M. WOODMAN, M.Sc. (Leeds), Ph.D. (Cantab.), F.R.I.C., F.Inst.P. (Resigned 30/9/52)
- Weed Ecology :** H. A. ROBERTS, B.Sc. (Manc.). (Appointed 1/5/52)
- Statistics :** J. A. NELDER, B.A. (Cantab.).
Assistant : Miss J. FARNSWORTH. (Appointed 7/1/52)
- Recorders :** Mrs. B. J. BOOKER. (Temporarily from 11/1/52 to 28/6/52)
 Miss S. E. HAIGH. (Appointed 11/1/52)
 Miss B. K. DUDLEY, Dip. Hort. (Notts.). (Appointed 5/8/52)
- Farm :** *Farm Manager :* T. J. NORWOOD.
Foreman, general farm cropping : E. F. ROBINSON.
Foreman, vegetable cropping : J. R. CASEBY.
 (Appointed 3/7/52)
- Administration :** *Secretary :* J. C. WILKINS, LL.B. (Lond.), F.C.I.S.
Accounts Clerk : J. H. L. BRIDGEWATER.
Clerical Assistants : Miss J. M. LAMB.
 Miss M. A. WARR.

REPORT OF THE DIRECTOR

During the early stages in the establishment of this Station the research staff, of necessity, were placed temporarily at different research institutes where they were kindly provided with facilities for their work. The first transfer of staff was possible in 1950-51 when two came to Wellesbourne. 1951-52 was a notable year for the Station, however, in that all the others of the research staff, with one exception, transferred to Wellesbourne and were joined later in the year by newly appointed staff ; the Station, therefore, began to function as a research centre. This had a stimulating effect on the staff in general. They felt that they now formed an integral part of the new station and that they would have an important part to play in its development. They appreciated the advantages of close association between the research, farming and administrative sides, and the benefits of co-operation between colleagues in different branches of research. They realised also that they formed the nucleus of a team of workers with pioneering work to carry out.

In 1951 the field experiments were kept as simple as possible because the research staff could visit the Station at intervals only, and vegetable cropping for experimental purposes was a new venture for the farm staff. In 1952 the field experiments were more elaborate and numerous, and about half an acre of vegetables was grown in frames with Dutch lights at the Station for the first time. As a result of the previous year's experience, however, the field workers had a better understanding of what was required of them and harmonious co-operation between research and farm staff solved any problems which arose.

The accommodation provided for the staff was all of a temporary nature and had to be equipped and adapted for research purposes. In this respect careful planning was necessary to make the maximum use of limited space and to ensure that, as far as possible, equipment and fittings could be transferred readily to permanent laboratories when these were built. With a beginning like this the needs of the staff were extensive and it revealed how much is taken for granted in the average research station in regard to the equipment, services and facilities which are at hand ; it is only when they are absent that it is realised how much effort is expended in providing them. In this connection the administrative staff gave great assistance. Some improvisation was necessary, of course, but despite various difficulties the staff carried out the programme of research in a remarkably able manner.

DEVELOPMENT

Progress in the development programme was made during the year. Work started on the sinking of a borehole on the western boundary of Pump Ground in November 1951, and was completed in June 1952. Results of the pumping test and of the analysis of the water were satisfactory and, after a local hearing, the Ministry of Housing and Local Government issued a licence under the Water Acts, authorising the Station to abstract water from the borehole up to a maximum daily quantity of 20,000 gallons. The Station will be required to measure and record the volume of water abstracted in each day. Plans, specifications and estimates of cost of the installation of water distribution mains, irrigation sub-mains, lines and accessories have been approved in principle by the Ministry of Agriculture and Fisheries, and the Treasury. Tenders have been invited, an immediate 'starting date' has been allocated and it is hoped that this work will soon be under way.

A contract was placed and, on the allocated starting date in May 1952, work began on the making of a concrete entrance road, a concrete road running north-south through the property, hard-core service roads to where farm-staff houses and glass-houses are to be built, and on the installation of main drainage and sewage disposal works. This will not be finished before the end of February 1953. Tenders are being

invited for the erection of farm stores (a section of which is to be fitted for use as temporary laboratories), implement and machinery sheds, a workshop, a grading, washing and packing shed, a building for threshing and storage of vegetable seeds, a canteen, a farm manager's house, and two pairs of cottages for farm staff whose duties require them to live on the farm. It is hoped that work on the erection of glasshouses and of buildings associated with them will begin in 1953.

The shortage of storage space for farming implements, etc., was relieved when a shed, 75 × 35 feet, was constructed of standard Ministry of Agriculture components in June 1952. Unfortunately, the old implement shed was condemned soon afterwards as being unsafe for further use.

As the research staff and work expanded, so the need for extra laboratory and storage space arose. This was met by the erection of two additional second-hand timber huts 40 × 12 feet and 63 × 16 feet, and the present total hutment accommodation may suffice until the temporary laboratories are built. More temporary glasshouses of the 'Dutch light' type were purchased and a bird-proof cage was erected for the protection of certain research crops.

An unexpected set-back occurred regarding the provision of houses for Station staff. As mentioned in the previous Annual Reports, the Stratford-on-Avon Rural District Council agreed to increase their housing programme in Wellesbourne in order to provide houses for Station employees. Nine of the first batch of nineteen houses were allocated to Station staff and it was understood that a number of houses would be allocated to them from the remaining group of forty houses when erected. In September, however, when these houses were nearing completion, the Council intimated that it could not allocate any of these houses to Station employees. Other means of overcoming the housing shortage are being actively investigated.

STAFF

A number of important additions to the staff were made during the year. Recruitment of well qualified and experienced research workers, and of skilled farm workers was difficult, however, partly because of a dearth of such workers and partly because of the lack of houses already mentioned. A few research posts, therefore, have remained unfilled, and hence it has not been possible to develop some aspects of the Station's work. On the farming side the effect of the shortage of skilled workers has been felt, and the difficulties have been aggravated by a turnover in the staff in excess of what may normally be expected. The latter is a consequence of the difficulty that most of the farm staff have in finding living quarters and of the inconvenience of travelling long distances to the Station.

Appointments

Dr. W. G. Keyworth took up his duties as Senior Plant Pathologist on 1st April, 1952. Dr. Keyworth came from East Malling Research Station, Kent, and is well known for his work on wilt and virus diseases on a number of plants, particularly hops.

Dr. J. A. Tomlinson, from the Ministry of Agriculture and Fisheries' Plant Pathology Laboratory at Harpenden, was appointed to the Plant Pathology Section on 16th June, 1952. Dr. Tomlinson spent two months at the National Agricultural Advisory Service (N.A.A.S.) Sub-Centre, Wye, Kent, to acquaint himself with the watercress work of his predecessor, Mr. Spencer, before starting his research at Wellesbourne.

Mr. H. A. Roberts of the Agricultural Research Council (A.R.C.) unit for research on weed control at Oxford University was appointed as Weed Ecologist on 1st May, 1952.

Mr. H. Holland and Mr. L. E. Watts were appointed to work in the Plant Breeding Section on 15th July, 1952.

Mr. J. Y. Ritchie and Mr. E. M. Watson were appointed as Assistant Experimental Officers in the Entomology and Plant Breeding Sections respectively during the year.

Nine Scientific Assistants and Recorders were also appointed to the various sections, two of whom served for less than a year, as was understood from the outset.

Mr. E. F. Robinson was promoted from farm worker to Foreman for general farm cropping on 1st October, 1951, and Mr. J. R. Caseby was appointed as Foreman for vegetable cropping on 3rd July, 1952.

Three students were employed to assist in research during the University summer vacation.

Mr. J. A. Galloway was appointed as Clerk of Works on 3rd June, 1952.

Resignations

Mr. D. M. Spencer resigned on 31st January, 1952, and took up work at Wye College, Kent. He was succeeded by Dr. J. A. Tomlinson.

Dr. A. H. Parkinson resigned on 15th March, 1952, to take up a post as Horticultural Superintendent at the Lancashire Institute of Agriculture, Hutton.

Mr. G. D. Sullivan resigned on 31st August, 1952, having accepted an appointment as lecturer in Agricultural Botany in the University of Sydney, Australia.

Dr. R. M. Woodman, who did not wish to transfer from Cambridge, resigned on 30th September, 1952.

Successors to Dr. Woodman, Mr. Sullivan and Dr. Parkinson have not yet been appointed.

A number of conferences and meetings were attended by members of the research staff during the year. The Director, Dr. J. C. Haigh, Dr. W. G. Keyworth, Mr. J. A. Nelder, Dr. J. A. Tomlinson, Mr. G. A. Wheatley, Mr. E. J. Winter and Mr. D. W. Wright attended the 13th International Congress of Horticulture held in London in September 1952, at which Mr. Wright read a paper on 'Soil insecticides for the control of cabbage root fly and carrot fly'. The Director, Dr. Haigh and Mr. G. D. Sullivan attended the Plant Breeders' Conference organised by the A.R.C. and held at Bayfordbury, Hertford, in July; Dr. Haigh read a paper on 'Variety testing'. Mr. Wright attended A.R.C. Conferences in London on Aphid Research and Brassica Viruses, and two Conferences of N.A.A.S. Advisory Entomologists, one at Harpenden and one in London; at the latter he read a paper on 'Recent work on the control of cabbage root fly and pea aphid'. Mr. Wright and Mr. Wheatley attended a Symposium on Problems in the Study of Insect Populations, sponsored by the Comité Européen d'Etudes de Zoologie Agricole (C.E.Z.A.) and held at Harpenden in September 1952. Mr. J. A. Dunn read a paper on 'The parasites and predators of the pea aphid' at the A.R.C. Conference on Aphid Research held in London in October 1951. In May 1952, Dr. Haigh attended a Conference in Truro on Broccoli Production and Marketing, organised by the N.A.A.S. in conjunction with the Cornish Branch of the N.F.U., and Mr. Nelder read a paper on 'Vegetable experiments' at a Conference on Field Experimentation held at Cambridge in February by N.A.A.S. Officers of the Eastern Province.

The scientific and administrative staff held its first Christmas-New Year party in January 1951. A most enjoyable evening was had by the group of twenty-seven people, thanks to the organisers and to wives of staff who did the catering, and especially to Mr. and Mrs. Bridgewater in whose spacious house the party took place.

RESEARCH

The scope of research was expanded during 1951-52 by the setting up of three new sections—pathology, irrigation, and weed ecology and weed control. Work on their programmes of research is still in its early stages and hence full accounts of the investigations being undertaken will be given in subsequent Annual Reports. Owing to staff changes, work was curtailed in the physiology section and in the watercress investigations.

Plant-breeding work was extended during the year to three additional crops—summer lettuce, red beet and spring cabbage. In each case, the first stage of the programme consisted of the collection and examination of a wide range of varieties in order to determine the range of variability within the crop, the degree of synonymy in varietal names and the quality of potential breeding material, and to enable the plant breeders to become familiar with the crop. The first crops of Brussels sprouts were grown from hybrid seed and showed sufficient promise to warrant more detailed study next year. Seed and bulbs of male-sterile onions were obtained from the U.S.A. in order to introduce the male-sterile character into breeding material with a view to simplifying the production of hybrid varieties. Nucleus stock seed was produced of established varieties for further multiplication and distribution by the National Institute of Agricultural Botany (N.I.A.B.), and of potential varieties which are in N.I.A.B. trials.

With the appointment of a senior plant pathologist during the year a pathology research section was established at the Station and a laboratory was equipped for this work. Before initiating work on a programme of research, a comprehensive survey was made of the pathological problems of the vegetable industry, covering the vegetable seed production side as well as the crop production side. Visits were paid to research stations and universities where investigations on vegetable pathology were in progress or had been carried out; discussions took place with N.A.A.S. officers, and growers were visited in most of the important centres of vegetable production. A study was also made of the literature on vegetable pathology.

Work on the pathology of watercress was interrupted from January to June 1952 by a staff change. Prior to this, further tests were made of fungicidal substances and nutrients in watercress beds, but none arrested infection of the roots by the crook root fungus. The favourable effect of glauconite on the growth of cress as reported in 1951 was not obtained in these second-year trials and hence judgment on the value of this mineral must be reserved. The new worker on watercress visited numerous watercress beds in several southern areas and familiarised himself with the methods used and results obtained by his predecessor, who was provided with facilities for his work at the N.A.A.S. Sub-Centre at Wye, Kent. This research is now being carried out at Wellesbourne, so that it forms an integral part of the work of the Station. Under this arrangement collaboration with growers and experiments on watercress holdings will be continued as before. Sources of diseased and healthy watercress were found near Wellesbourne, which will augment supplies obtained from growers elsewhere. Some of the earlier experiments have been repeated satisfactorily, and other experiments have given useful information on the assessment of crook root disease and its effects on the plants. Research has been resumed on the life history of the fungus, on the effect of environmental conditions on the progress of the disease, and on factors which may help to suppress it in commercial beds.

Experiments were continued and extended on the effectiveness of various insecticides, applied in different ways, for the control of cabbage root fly on brassica crops. In general, the results confirmed those obtained previously and substantial increases in yield were produced with summer and autumn cauliflowers following the control of the cabbage root fly. With a given dosage of gamma BHC, the degree of control obtained was found to increase with increase in concentration of the insecticidal solution used. As before, it was shown that with both liquid and dust formulations the insecticides were most effective when placed on a limited area of soil around the plant. Some insecticides, *e.g.*, DDT, appeared to be more toxic to predatory and parasitic insects which normally prey on the cabbage root fly larvae and pupae, than to the pest itself. When such insecticides are used in the field, they may remove to a great extent the restraining influence of natural predators and parasites on the population of the pest, so that heavy infestations and damage may result. Other insecticides, however, can be used in such a way that these adverse effects are avoided.

Further work was done on the control of carrot fly. Carrot seed was treated at various rates with a gamma BHC dust and it was found that the degree of control

increased with increased dosage, and was virtually complete at the higher levels of treatment. Samples of carrots from the different treatments have been submitted for analysis to detect the presence of any insecticidal residues, and have been canned prior to tasting tests being carried out.

Biological studies on the pea aphid and its natural enemies were continued. Data were obtained on the feeding, development and field behaviour of a newly-found lacewing predator which showed that, in sheltered fields of lucerne, it could be at least as important as the hoverfly as an aphid-controlling factor.

An experiment demonstrated the relative effectiveness and persistence of different insecticides in controlling cabbage aphid on cabbage plants. HETP, BHC and parathion were applied as foliage sprays, and the systemic insecticide, Pestox 3, was applied to the foliage and to the soil. HETP gave a high initial kill with a residual action of less than 24 hours. BHC gave a high initial kill and a strong residual action lasting for three days. Parathion gave a very high initial kill and a strong residual action lasting for seven days on the heart leaves and for 21 days on the outer leaves. Pestox 3 gave a rapid kill which was complete after five days and was maintained for a further nine days. Small numbers of aphids then appeared on the heart leaves and multiplied slowly during the next two months. This restraining effect of the Pestox 3 residues on aphid multiplication was greater with the soil than with the foliage treatment. Aphids were unable to colonise the outer leaves for about three months.

Experiments have shown that spray treatments for the control of pea moth can also control attack of the pea crop by leaf miners. They have shown also that in some years, when there is a bad attack by leaf miners, control by the above means can result in an increase in the yield of dried peas of about five hundredweights per acre. Spray treatment with DDT emulsion should be given as soon as small mines are noticed on the foliage or when leaf miner flies are seen. If, however, the attack has reached an advanced stage with many larvae and large mines in the leaves, it appears that spraying with parathion will give a better control than DDT emulsion.

Studies on the particle sizes of insecticidal dusts were continued and have indicated that the velocity of the air passing a target of given size has a direct effect on the size range of the particles deposited on the target. This has an important bearing on the efficiency of insecticidal treatment with an impregnated DDT dust mixture, since the inherent toxicity of the dust particles varies with the size of the particles, the larger particles being the more toxic to the pea aphid.

Four small constant-temperature chambers have been constructed for use in studying the effects of temperature on the larval and pupal development of the pea moth and on other insects. These cabinets embody heating and cooling devices, and can be operated above or below ambient room temperature, their useful range being about 35–75°F., with a small overall temperature variation of the order of $\pm 0.2^\circ\text{F}$.

Apparatus for use in the study of the effects of overhead irrigation was designed jointly by the National Institute of Agricultural Engineering (N.I.A.E.) and the N.V.R.S., and was constructed by the former Station. The apparatus is suitable for experiments having small plots and is capable of applying water to the soil evenly, at a prescribed rate and in exact amounts. It consists essentially of a line of nozzles which stretches across one side of the plot and is moved, on rails, over the plot. The apparatus was calibrated and modified at Wellesbourne during the summer of 1952, and it performed satisfactorily in two experiments with radishes in the autumn. Regarding plot dimensions, the length of one side of the plot depended on the length of the line of nozzles—in this case 16 feet—and it was found that for effective use of the apparatus, the width of the plot, *i.e.*, the distance traversed by the line of nozzles, should not be less than five feet. The apparatus gives promise of being most useful for the investigation of the effects of irrigation and it may also prove to be a valuable tool for other lines of research, *e.g.*, in the study of soil erosion.

Irrigation experiments with radishes in the autumn of 1952 showed that water applied immediately after sowing encouraged rapid germination and gave a high percentage germination; $\frac{1}{4}$ -inch of water, including rain, appeared to be adequate

in this respect. They also provided evidence which indicated that the crop grew better if it received about $\frac{1}{2}$ -inch of water, including rain, per week. The irrigation treatments brought about an increase in the number and size of marketable bulbs and in the amount of leaf; they also increased the number of small unmarketable bulbs.

Investigations have been continued on the problem of the unreliability of the germination of Cheltenham Greenleaved Beet. Crosses were made to examine the problem from the genetic viewpoint, and several factors affecting germination were studied but the evidence obtained so far does not permit any conclusions to be drawn. The results of an experiment on spacing of summer lettuce confirmed those obtained in 1951, namely that close spacing delayed hearting and bolting.

A field experiment was laid down to test the effects of the new synthetic resin soil-conditioner, 'Krilium'. Different dosages of 'Krilium' were incorporated in the soil to two depths, three and six inches, and the first crop of a two-year rotation of peas, spring onions, lettuce and carrots was grown. 'Krilium' produced an obvious difference in the texture of the surface soil which was less 'panned' than that of the untreated soil. It also increased the yield of peas but irrigation treatment during dry weather in May and June, without 'Krilium', gave a still higher yield.

A good beginning has been made on the study of weed ecology and of weed control as it affects vegetable production. In devising effective methods of weed control by either cultural or chemical means, it is useful to have knowledge of the ecology of weeds, and studies have therefore been started on the factors connected with the success of certain weeds in vegetable crops, such as the longevity of weed seed in the field, the seasonal variation in germination, the duration of the weed's life-cycle and the rate and volume of seed multiplication of different weed species.

Promising results were obtained with onions and lettuce, using pre-emergence herbicidal sprays of mineral oils containing pentachlorophenol, and different pre-emergence herbicides were tried on peas and red beet. Post-emergence applications of DNBP (ammonium 2,4-dinitro-6-secondary butyl-phenate) on peas gave good results. A fairly new chemical, CMU, 3-(p-chlorophenyl)-1,1-dimethylurea, was tested on several vegetable crops as a pre-emergence herbicide. It gave excellent control, even at $\frac{1}{2}$ -lb. per acre, but had no effect on *Fumaria officinalis* (Fumitory,) and little effect on *Veronica hederifolia* (Ivy-leaved Speedwell). CMU is rather insoluble but when it enters the plant, mainly through the roots, it is highly toxic. Rainfall has a great influence, therefore, on the effect of CMU and it was found that heavy rain shortly after the application of CMU caused it to kill onions. Further work with this chemical is necessary.

On the statistical side, assistance was given on experimental design, technique of sampling, and analysis of data to the Station's research staff and also to the N.A.A.S. Experimental Horticulture Stations and Provincial Experiments Committees, the Marketing Division of the Ministry, the Fruit and Vegetable Preservation Research Station, Campden, the School of Agriculture, Nottingham University, and the Ditton Laboratory of the Department of Scientific and Industrial Research. Further crosses were made between varieties of the French bean in connection with the study of the genetics of continuous variation. It was also shown experimentally that short lengths of single-span or double-span frames can be used in experiments with lettuce, and presumably other vegetables, under Dutch lights provided that the Dutch light at each end is regarded as a guard light, thus allowing for end effects on the crop.

N.A.A.S. Experimental Horticulture Stations have been set up by the Ministry at intervals since 1949 and close relationships have been maintained between them and this Station. The Director has acted as Chairman of the Vegetable Working Party which co-ordinates the experimental work with vegetables on these stations, and he has served on the Advisory Committees of the Stations. Field experiments with

vegetables were carried out during the year at the Luddington Station, near Stratford-upon-Avon, and at the Stockbridge House Station, near Selby, in extension of experiments carried out at Wellesbourne by the Entomology and Plant Breeding Sections. The collaboration of these stations in this work is much appreciated.

Seed Maintenance and Multiplication

When, in 1949, the N.V.R.S. took over the material bred at the Cambridge H.R.S. the maintenance of the Cambridge varieties of vegetables became the responsibility of the Station. The practice had been for the plant breeders to hand over small amounts of high quality seed (nucleus stock seed) of the Cambridge varieties to the N.I.A.B. who multiplied this seed for one generation. The product (stock seed) was distributed in sealed bags by a Seed Trader to other members of the Seed Trade and to seed growers and commercial growers. Thus some of this stock seed was used as material for further multiplication of seed supplies and some for vegetable production. This system was functioning reasonably satisfactorily and it was continued with the valued co-operation of the N.I.A.B. The Governing Body of the N.V.R.S., however, felt that the system might be improved upon and, after joint discussions with representatives of the N.I.A.B., the Seed Trade Association (S.T.A.) and the N.F.U., the following basic principles of a new scheme were agreed upon.

The N.V.R.S., as before, will provide the N.I.A.B. with small quantities of highly selected nucleus stock seed of the Cambridge varieties and of other varieties produced by the Station. The N.I.A.B. will multiply this seed for one generation, producing stock seed but in smaller quantities than before. The N.I.A.B. will then distribute this stock seed to a group of recognised seed growers recommended by the S.T.A., the N.F.U., and the N.F.U. of Scotland. These seed growers will multiply the stock seed for one generation only, thus producing commercial seed, and they will obtain fresh stock seed from the N.I.A.B. for each multiplication. The commercial seed of each multiplier will be sampled and grown by the N.I.A.B. in a centralised trial. If it passes this test, the commercial seed will be sold as certified and approved seed. If, however, the seed has to be sold before the result of the growing-on test is known, a statement will be provided to the effect that it had been grown from N.I.A.B. stock seed and that it had been sampled for inclusion in an N.I.A.B. growing-on test—the N.I.A.B. stock seed number will also be given.

It is generally agreed that this scheme should have advantages over that which it is to replace. Some details in the working of the scheme have yet to be arranged but this is not hindering it from being put into operation; the first stages which concern the N.V.R.S. and N.I.A.B. are under way and, owing to the time factor in vegetable seed production, a few years must elapse before certified and approved seed will be on the market. The full co-operation of all concerned in the scheme will be necessary for its success and the helpful and harmonious relationships which have existed in its initial formulation augur well for the future.

FARMING OPERATIONS

The weather during 1951-52 was better than that of the previous year for farming operations. At Wellesbourne, the 1951 potato harvest was completed by the end of October, but the weather broke in November and only two-thirds of the wheat was sown in the autumn, the remainder being delayed until February. The 1952 corn harvest was early and the last load was stacked on 21st August. The early harvest was followed by good weather which allowed progress to be made with the winter cultivations. The root crops, particularly potatoes, were affected adversely by a dry period in June and July but the rains in August had a beneficial effect on them. The policy of clearing the land and building up soil fertility was continued and hence a considerable acreage was green manured; the land cleared of the 1951 vegetable crops was sown with a clover ley mixture and grazed by cattle during late summer and autumn.

79 cattle were wintered in the yards and fed entirely on products of the farm. 24 were sold, fat, in April and May, and four in August. The rest were grazed on the young leys which were not required for hay or silage. The silage made in 1951 had the unusually high protein content of 23.5 per cent. of the dry matter. 45 store pigs were bought in May, fattened in the yards and sold in September and October. All the dung from the above livestock will be used to build up the soil fertility to the level required for vegetable cropping for research purposes.

Some additional farming equipment was purchased during the year so that the position in this respect is now satisfactory. Worthy of mention is the purchase of a motor lorry, a crawler tractor, and a 'station waggon' which has given valuable service in the transport of staff in connection with their work on the Station and further afield.

Among the improvements carried out during the year was the installation of a tile drainage scheme in Soakwaters, and the clearing of water from the large pit in this field by the opening and rodding of an existing tile drain which leads to the River Dene, thus allowing the pit to be brought back into cultivation. That part of the farmyard between the farm buildings and the Dutch barn was cleared of slurry and covered with hard-core and ashes, as also were several of the farm roadways. The roof of the small piggery was completely stripped, re-timbered and re-tiled. A new shed was erected adjacent to the farmyard to house some of the implements. The roof of the Dutch barn was renovated and made water-tight, the windward side was partly covered with corrugated iron sheets, and the bases of the steel stanchions were reinforced with concrete.

Four hedges which were rabbit-infested and consisted mainly of elm stumps and their suckers, elderberry and brambles, were removed; these were on the east and west sides of Little Cherry Ground, and on the boundaries on the east and west sides of Wellesbourne Gravel Pits and Sheep Pens respectively. The ninety-odd tree stumps were removed by blasting and were burned. The boundary hedges were replaced by concrete posts and four-foot-high chain-link fencing, which was buried in the ground as a barrier to rabbits. Post and wire-netting fences were erected also around Big Cherry Ground and a portion of Wellesbourne Gravel Pits to prevent rabbits from entering the areas under experimental vegetable crops.

At Paglesham, the 1952 crops were about average. Nearly all were affected to some extent by adverse weather during the spring but those least affected were the winter cauliflowers and potatoes which followed green manuring, the potato crop being exceptionally good. Peas were sown at intervals between late March and early May, and it was found that the earlier sowings did better than the later ones. Seed crops of various vegetables were grown during the year.

Visitors

The number of visitors to the Station during 1950-51 was 76, and during 1951-52 was 84. Among them were the following from overseas :—

<i>Australia :</i>	Mr. K. D. Brock, C.S.I.R.O., Canberra. Prof. J. A. Prescott, Director, Waite Institute, Adelaide.
<i>Denmark :</i>	Mr. P. Norige Pedersen, Rolighedsvej, 23, Kobenhavn.
<i>Egypt :</i>	Mr. Anwar El Behery, Ministry of Education (Agricultural Section), Cairo.
<i>France :</i>	Dr. E. K. Janaki Ammal, Institut National Agronomique, Paris.
<i>Holland :</i>	Dr. H. F. Waterschoot, Lab. Tuinbouwplantenteelt, Wageningen. Prof. S. J. Wellensiek, Lab. Tuinbouwplantenteelt, Wageningen.
<i>Italy :</i>	Dott. Giovanni Friedmann, Corso di Porto Romano 122, Milano.
<i>New Zealand :</i>	Mr. A. M. W. Greig, Horticultural Division, Dept. of Agriculture, Wellington. Miss Greta Priestley, Vegetable Section, Crop Research Division, D.S.I.R., Lincoln.
<i>Norway :</i>	Dr. Jens Roll-Hansen, Director, State Experimental Station for Vegetables, Experimental Farm, Kvithamar, Stjoldal.
<i>South Africa :</i>	Prof. H. Shaw, Director, Wattle Research Institute, University of Natal, Pietermaritzburg.

<i>Sudan :</i>	Mr. Kenneth Wilson-Jones, Gezira Research Farm, Wad Medani.
<i>Sweden :</i>	Dr. Robert Lamm, Horticultural Research Station, Alnarp, Akarp.
<i>United States of America :</i>	Mr. T. G. Gillespy, 63 College Park, Davis, California. Prof. J. E. Knott, Dept. of Vegetable Crops, University of California, Davis, California.
	Dr. Chas. F. Poole, University of Hawaii, Honolulu 14, Hawaii.
<i>Yugoslavia :</i>	Dr. Ing. Elza Polak, Faculty of Agriculture, University of Zagreb.

Acknowledgments

Acknowledgment is made to the Agricultural Land Commission for the assistance given in carrying out the farming work at Paglesham.

Special acknowledgments are due to those members of the staff who have carried out duties in addition to their normal work. Mr. Winter has continued to give valuable assistance in connection with the planning of new buildings, glasshouses and an irrigation system. He also supervised the organisation of the library. Miss Farnsworth, Miss Purdy, and Messrs. Nelder, Bridgewater and Wheatley served on the Canteen Committee. Mr. Nelder again assisted in the editing of this Annual Report.

Grateful acknowledgment is also made to all the staff and employees for the loyalty with which they carried out their work.

Thanks are due to the Executive Committee and Sub-Committees for the assistance they have given. Special thanks are extended to Dr. H. V. Taylor who has completed his three-year term as Chairman of the Executive Committee (succeeded by Mr. David Lowe), and has been elected Chairman of the Governing Body ; to Professor W. Brown, Mr. F. A. Secrett, and Mr. W. F. Swift, who have been re-elected as Chairmen of the Staff and Research, Buildings, and Farm Management Sub-Committees respectively ; and to Mr. J. S. W. Cracknell for work he has done in connection with financial matters.

Thanks are also due to all those friends of the Station, particularly growers and commercial firms, who have helped in many ways.

J. PHILP,

30th January, 1953.

PLANT BREEDING REPORT

By J. C. HAIGH

The transfer of operations from Cambridge to Wellesbourne was completed by the end of September 1951, and work during the year under review has been done either at Wellesbourne or Paglesham.

Seed Production

Nucleus stock seed was produced of the varieties listed below :—

Varieties which have been distributed

Brussels Sprouts	..	Cambridge No. 5
		Cambridge Special
Winter Cauliflower	..	Cambridge Hardy Late
		Cambridge Dwarf April
Early Cauliflower	..	Cambridge No. 6
		Cambridge No. 7
Onion	..	Cambridge No. 2
		Cambridge No. 10

Varieties, trials of which are not yet completed

Cabbage	..	Cambridge Drumhead
		Cambridge February
Onion	..	Cambridge No. 1

Promising varieties not yet included in trials

Winter Cauliflower	..	Cambridge X 12
Early Cauliflower	..	Cambridge No. 8
Cabbage	..	January King selection
Onion	..	Cambridge Nos. 28 and 33

No. 5 Brussels sprout, No. 2 onion and Hardy Late winter cauliflower stocks were raised at Paglesham, the rest at Wellesbourne. Seed was produced of breeding material of peas and onions at Wellesbourne and of carrots at Paglesham.

Plants of the following varieties were grown for selection and the production of nucleus stock seed in 1953 :—

Brussels Sprouts	..	Cambridge Special
Cabbage	..	Cambridge Drumhead
		Cambridge February
		Cambridge Red
Onion	..	Cambridge No. 10

The Brussels sprouts and onions were grown at Paglesham, and the cabbage varieties at Wellesbourne.

Plots were laid down for the maintenance of breeding material of onions, carrots and Hamburg parsley.

Incidence of Natural Crossing

Seed was harvested from a plot in which the sprout varieties Cambridge No. 3 and Cambridge Special had been planted in alternate rows and had been left to inter-pollinate by natural agencies. There were approximately 100 plants of each variety in the plot and the varieties were harvested separately. It is proposed to grow samples of this seed and to ascertain what degree of intervarietal crossing has taken place.

Small plots of different varieties of *B. oleracea* (thousand-head kale, red cabbage, savoy and Kohl-rabi) have been established at scattered points on the Station in order to determine the degree of isolation necessary for seed production in brassica crops. The varieties used are such that it should be possible to identify natural hybrids between any two of them, and distances between plots vary from two to seven furlongs.

Work on New Crops

Work was started during the year on three new crops—spring cabbage, cabbage lettuce and red beet. In all cases the first stage of the programme took the form of an examination of existing types, in order to appreciate the range of variability within the crop and the degree of synonymy in commercial varieties; to this end data were collected on morphological characters, on yield and on quality. In the trials there were 295 varieties of lettuce, 169 of red beet and 138 of spring cabbage, including representatives from the continent of Europe and from North America.

Work at Outside Centres

The search for resistance in sprouts to ringspot caused by *Mycosphaerella brassicicola* has continued. Those plants in the trial at Trawscoed (see report for 1950-51) which had shown comparatively little attack were seeded in isolation, and plants grown in Devon from this seed again showed less attack than a collection of varieties with which they were interplanted. It was arranged that seed from these plants should be seeded in isolation in Cornwall in 1952. Grateful acknowledgment is made of the co-operation of local N.A.A.S. officers, of Mr. Cave, on whose land the trials were grown, and of Mr. Plumb who supervised this work.

Spacing trials with Cambridge Drumhead Cabbage were carried out at Luddington and Stockbridge House Experimental Horticulture Stations of the N.A.A.S., with the valued co-operation of the Directors and staffs of those stations. Cambridge Drumhead has been included in N.I.A.B. trials for the past three years, but always at the spacing common to other Drumhead varieties, which operates to its disadvantage, since it is a small version of the Drumhead type (see report for 1949-50). It is therefore desirable that the optimum spacing for this variety should be determined. The trials will be repeated and extended in 1953.

Miscellaneous

A start has been made on an inbreeding programme for brassica crops by the production of clonal material of brussels sprouts.

As in the past, multiplication of nucleus stock seed of the Cambridge varieties of vegetables was done by the N.I.A.B., and assistance was given to its staff in the inspection and roguing of seed crops.

SILVERING DISEASE OF RED BEET

A preliminary account

By W. G. KEYWORTH

This disease has occurred in seed crops of the Cheltenham Green Top variety of red beet for several years. It is now being studied at the N.V.R.S. and this brief account of its symptoms and occurrence is therefore given for the guidance of growers. The writer's observations are confined to 1952, but information on the past occurrence of the disease has been supplied by growers and other workers.

Symptoms

For the production of seeding plants, Cheltenham Green Top seed is sown in August. The plants grow thickly in the steckling (seedling) bed and are transplanted to their permanent site when their tap roots are over $\frac{1}{4}$ -inch thick. This is usually done either in November or in March. Bolting of the plants occurs in the spring, the main shoot then being trimmed back to encourage lateral production. The plants should attain a height of $2\frac{1}{2}$ –4 feet and produce a tap-root 2–4 inches in diameter. The seed is harvested in September and an average yield is 7–10 cwt. per acre.

The first obvious symptoms of silvering usually appear in April-May, after bolting has started. Then, a few leaves on the main stem or on one of the lateral branches turn silvery-grey in colour. This coloration may be evenly diffused through the leaf or may be more intense along the veins. Soon the whole branch is affected and the leaves start to wilt. Other laterals are then involved and within a few days all the leaves on the plant become silvered and then wilted. Finally, the leaves shrivel up and the plant dies. The tap-roots on severely wilted plants are sometimes rotted, especially near the crown, but this is not invariable, and there is no evidence that the rotting is the cause of the silvering.

Plants may show symptoms at any time from April to September and, occasionally, affected plants have been seen in the steckling bed. In 1952 disease incidence attained a peak in June-July and declined subsequently, and in many fields 40–75 per cent. of the plants were killed. In some cases the seed crop was reduced to under 2 cwt. per acre.

History and occurrence

Although seed crops of Cheltenham Green Top beet have been grown for at least 30–40 years in Britain, the disease was not reported until 1945. It then occurred on at least two farms in Essex and one in Kent and caused considerable loss (1). Since that time it has been reported from many farms in both counties. It must be presumed that since it was not noticed before 1945, it was not prevalent before that date and its comparatively sudden and widespread occurrence remains unexplained. There is no clear evidence of any spread from farm to farm, nor of any correlation with soil conditions. A further point of interest is the fact that it is apparently confined to seeding crops and has never been reported on beet grown for roots.

So far as is known at present, the disease affects only the variety Cheltenham Green Top. As this variety is widely grown in Southern England, however, the presence of such a severe disease in the seed crop is of importance.

Conclusion and future research

The cause of this disease is at present unknown, but it seems most likely to be a virus. The study of this possibility is the first object of future research. The source

of the disease must then be determined, as well as its mode of transmission, so that attempts can be made to eradicate it. As a first step in this research, young plants have been raised in 1952 on affected farms, in an attempt to obtain experimental material for testing in 1953. Seed has also been collected from diseased and healthy plants.

The co-operation of growers in this work is very necessary, and it will greatly assist the research if those who suspect the disease in their crops will report it, either through the N.A.A.S. or direct to the Research Station.

Acknowledgments

The writer is grateful to all those who have collaborated in the experimental work in 1952 ; also to members of the staff of the N.A.A.S., the N.I.A.B. and Rothamsted Experimental Station who have placed their previous records freely at the writer's disposal.

REFERENCE

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THE CONTROL OF PEA LEAF MINERS

(Diptera. *Agromyzidae*)

By J. A. DUNN and D. W. WRIGHT

INTRODUCTION

The pea crop is subject to attacks by a number of insect pests ; some, such as the Pea Moth and the Pea Aphid, frequently cause considerable damage, whilst others only occasionally occur in sufficient numbers to affect the crop seriously. Pea leaf miners come into the latter group and, because of their irregular occurrence, they have been largely disregarded and little or no attention has been given to their control. Warburton (1) stated in 1925 that pea leaf miners could cause much damage.

In 1948 the incidence of leaf miners on peas in East Anglia was considerably above average and the opportunity was taken to assess the effect of chemical treatment on such a high infestation. In 1949 further field experiments were carried out to check the findings of the previous year.

Biology

Pea leaf miners are a complex of several species of leaf mining Diptera. In an experiment at Algarkirk, Lincs. in 1948, the species *Phytomyza atricornis* Mg. predominated and *Liriomyza* spp. came next in order of abundance. In the 1949 experiments carried out at Cambridge these species were again the most abundant but *Liriomyza* spp. outnumbered *P. atricornis*.

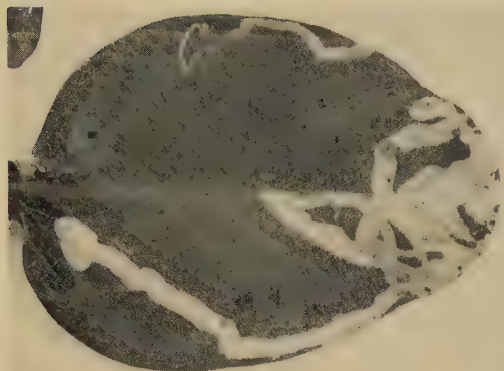
The life cycles of the common species are very similar. The eggs are laid in small incisions made in the foliage by the adult females. The larvae, on emerging, make their way into the mesophyll and feed on the parenchymatous tissue. They form feeding channels or mines between the upper and lower epidermis. The mines vary in shape with the species, those of *P. atricornis* being characteristically serpentine, whilst other species produce blotch-like mines (see Plate I). When more than one larva is present in a leaflet, the mines often coalesce and lose their specific characters. The larvae of most species, upon reaching maturity, drop to earth to pupate ; with *P. atricornis*, however, pupation takes place in the leaf at the end of the mine.

All the species of leaf miners found on peas may also breed on other host plants, the most polyphagous species being *P. atricornis*, which has been recorded from over 120 different kinds of plants. As some of these plants are common weeds of agricultural land, the leaf miners are largely independent of the pea crop for survival. They show considerable variation in yearly abundance on both peas and weeds, however, and in localities where alternate hosts are prevalent the population of these insects is probably larger than in places where such hosts, including weeds, are comparatively scarce. The leaf miners suffer very heavy mortalities from insect parasites and these must play an outstanding role in preventing their hosts from becoming major pests of frequent occurrence.

1948 Experiment

In 1948 a field experiment carried out at Algarkirk, Lincs., was designed primarily to test various treatments for the control of the Pea Moth. A twelve-acre field of Harrison's Glory peas was divided up into twelve plots each measuring 60 × 80 yards. This gave a randomised block layout of three replicates of each of three spray treatments and a control. A 0.25 per cent. DDT emulsion was used exclusively and was first applied to all sprayed plots ten days after the crop had begun flowering. A second spray application, designed to cover new plant growth, was given three and four weeks after the crop was first sprayed, to treatments 2 and 3 respectively. Details of the treatments are shown in Table I.

PLATE I



A. Pea leaf showing damage caused by leaf-miner
Phytomyza atricornis Mg.



B. A portion of a pea plant showing damage caused by the
larvae of several species of leaf-mining Diptera.

TABLE I

Rates and times of application of an emulsion containing 0.25% DDT

Treatment	Date of application
1. 1 spray application at 170 gallons/acre	25th June
2. 2 spray applications—1st at 170 gallons/acre 2nd at 200 gallons/acre	25th June 16th July
3. 2 spray applications—1st at 170 gallons/acre 2nd at 200 gallons/acre	25th June 23rd July
4. Unsprayed (control).	

The sprays were applied by a power operated machine fitted with back and side tool bars to which spray nozzles were attached. The latter were arranged so that the cones of spray just overlapped at crop level. The spray was delivered at a working pressure of 375 lb./sq. in. through fine nozzles (diameter of aperture 3/64 in.). This gave a highly dispersed mist-like spray which produced a continuous cover of the upper foliage, whilst a fine discontinuous cover extended even into the most dense parts of the crop. Favourable weather at the times of spraying resulted in little spray drift and in all cases, drying was good. When the second spray applications were made, the remains of the deposit of the first spraying were still visible. To prevent damage by the wheels of the spraying machinery, the foliage was moved clear of the appropriate inter-row spaces.

Although the experiment was designed to test the different treatments for the control of the Pea Moth, the cool, wet weather prevailing during the main flight period of the adults checked the infestation by this insect considerably. Samples taken in late July showed an average pod infestation by Pea Moth larvae of 1.3 per cent. on the untreated plots, whilst the attack varied from 0.0 to 0.4 per cent. on the treated plots. The weather was also unfavourable for the development of attack by the Pea Aphid, and samples taken at several stages of crop growth showed that the numbers of this pest were so small as to be of no economic importance. The effect of both Pea Moth and Pea Aphid could, therefore, be neglected.

The leaf miners, however, were not adversely affected by the weather and heavy infestations developed on the control plots and on many unsprayed pea crops in the same locality. The treated plots were conspicuously greener and more vigorous than those not treated and when plant samples were taken on 21st July it was estimated that 30 per cent. of the foliage on unsprayed plots was mined, whilst on the sprayed plots the foliage damaged never exceeded 5 per cent.

The plant samples consisted of 25 complete plants per plot, taken singly and at random along the plot diagonals. These were examined and the mines were graded into two categories according to size. Mines which were less than one quarter full size were termed 'small' and those which exceeded one quarter full size were termed 'large'. The examination, however, proved very time-consuming and it was only possible to complete the work on the samples from all the replicates of treatments 3 and 4 (control). The average number of mines present per plant is shown in Table II. Single replicate samples from treatments 1 and 2 showed levels of infestation similar to treatment 3.

It will be seen that the spray treatment brought about considerable reduction in the number of larger mines but this effect was much less marked with the smaller mines. The latter, however, were mostly on the upper and younger foliage which had developed after the spray had been applied.

TABLE II

The effect of treatment on mine numbers

Treatments	Average number of mines per plant	
	small	large
3. Sprayed with 0.25 per cent. DDT emulsion, 25th June	1.89	1.17
4. Unsprayed	4.54	18.00

To estimate the yield following the various treatments, samples were taken on 3rd August just prior to the harvesting of the crop. Eight random samples, each comprising all the plants from one yard of row were taken from each of the twelve plots. The pods in these samples were counted, dried and thrashed, and the dried peas weighed. The yield per acre for each treatment was calculated and the results are given in Table III.

TABLE III

The effect of 0.25 per cent. DDT emulsion treatments on yield and pod numbers

Treatment	Average weight of dried peas/acre cwt.	Improvement in yield over control, cwt./acre	Average number of pods/yard of row
1. Sprayed 25th June ..	20.84	3.34	167.29
2. Sprayed 25th June and 16th July ..	21.25	3.75	169.08
3. Sprayed 25th June and 23rd July ..	23.04	5.54	172.08
4. Unsprayed	17.50	—	148.62

Significant differences at 5 per cent. level :—

Yield

4 < 2 and 3 ; no differences between 1, 2 and 3.

Pod numbers

4 < 1, 2 and 3 ; no differences between 1, 2 and 3.

The yield of dried peas and the pod numbers have similar significant differences. This is to be expected for yield is dependent on pod numbers, but the relationship that exists in Table III between pod numbers and yield is not direct, since many of the pods included, especially from treatment 4, were flat and unproductive.

It will be seen from the Table that the effect of a single spray treatment was to increase the pod population by 12.6 per cent. and the yield of dried peas by nearly 20 per cent. as compared to the control. The increase in yield of dried peas, however, just failed to reach statistical significance due to a high standard error. Where two spray applications were used, both treatments (2 and 3) showed significant increases

and in treatment 3, where the second spray was applied four weeks after the first, the increase in yield of dried peas was 31.6 per cent. compared with the untreated plots. An interval of four weeks between the first and second applications appeared to be more effective than a three-week interval. This was probably due to the later spray's coinciding more closely with the appearance of the second generation of leaf miners on the peas and, in consequence, being more effective.

1949 Experiments

In 1949 replicated experiments were carried out in Lincolnshire on a field basis, and at Cambridge using small plots. As in 1948, the treatments used were designed primarily for the control of the Pea Moth, but further observations were made on the value of sprays for the control of pea leaf miners and data were obtained on the effects of certain of the sprays on the larval stage of these insects. At both places leaf miner attacks had already begun when the peas were sprayed and many mines were present in the lower foliage.

Observations made on the Lincolnshire experiment showed that, as in the previous year, a single application of 0.25 per cent. DDT spray gave a very substantial degree of control and 15 days after spraying, it was estimated that the amount of foliage damaged had been reduced from 25 to 8 per cent.

On the Cambridge plots, plant samples were taken eight days after spraying: the number of mines was counted and condition of the larvae noted. The treatments used and the results obtained are given in Table IV.

TABLE IV

The effect of DDT emulsion and parathion on the larvae of pea leaf miners

Treatments	mines	Average number per plant			
		larvae			
		dead		living	
		small	large	small	large
1. 0.4 per cent. DDT emulsion ..	27.4	8.2	0.8	5.2	2.7
2. 0.05 per cent. parathion emulsion	15.5	11.8	1.7	0.0	0.0
3. Unsprayed	33.0	3.0	0.1	13.5	6.5

It will be seen that DDT emulsion caused considerable mortality of larvae inside the mines particularly of the smaller individuals. Parathion caused complete mortality of all larvae, however, and in addition excelled DDT in checking the formation of mines.

DISCUSSION

Pea leaf miners have been shown to be capable of producing a major reduction in yield in a year when they are abundant. Although it is not possible to predict years of peak incidence, the routine spraying measures adopted by many growers for the control of the Pea Moth can serve also to safeguard the crop against leaf miners. The control thus extended, can give an increased yield of five hundredweights or more of dried peas per acre. Where routine spraying for the Pea Moth is not practised,

then control measures directed solely against leaf miners would be economically sound in seasons when the latter are abundant. The decision as to when to spray must rest largely on the observance of the numbers of flies or small mines in the crop, and when either or both are present a DDT emulsion should be used immediately. Where the attack is advanced, however, with many larvae in the leaves, it would appear better to use a parathion spray.

SUMMARY

1. The incidence of pea leaf miners was very high in 1948 and widespread attacks occurred on peas in East Anglia. In 1949 they caused much less damage.

2. A field experiment in Lincolnshire in 1948 showed that a good control of pea leaf miners could be obtained with 0.25 per cent. DDT emulsion applied as in the control of the Pea Moth.

3. Where two applications of the spray were made, the second four weeks after the first, the yield of dried peas was increased by more than $5\frac{1}{2}$ cwt. per acre as compared with the control.

4. Although DDT killed larvae of pea leaf miners when they were inside the leaves, better results followed when it was applied at the onset of attack and before extensive foliage-mining had occurred.

5. In the 1949 experiments, a parathion spray gave a complete kill of larvae already in the foliage which suggested that this chemical might be used, in preference to DDT, when the attack by pea leaf miners was well under way.

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A COMPARISON OF THE EFFECTIVENESS OF CERTAIN INSECTICIDES FOR THE CONTROL OF THE CABBAGE APHID (*Brevicoryne brassicae* L.)

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Introduction

A considerable number of insecticides are now available which may be used for the control of the cabbage aphid (*Brevicoryne brassicae* L.). They differ not only in their toxicity to the aphid but also in the length of their persistence on or in the plant and in their effect on the various natural enemies of this insect. These characteristics play an important part in determining the choice of insecticide to be used in the field. Thus, with crops which are to be marketed within a few days of treatment, residues of the insecticide are undesirable and materials which rapidly disappear should be used (*e.g.*, HETP or nicotine). Where the crop is not to be harvested for a considerable time, an insecticide which not only gives a high initial mortality of the pest but also leaves a lasting toxic residue has obvious practical advantages (*e.g.*, parathion, schradan).

The importance of the beneficial insects as natural agents which restrain the population of a pest should not be under-estimated. Their preservation when using insecticides is most desirable, especially on crops which are immature and on which a general insecticide, killing all insects present, may lead to severe crop loss following re-infestation, and rapid increase of the pest. In certain cases, however, where a crop is to be processed for food and is required to be free of all insects, it may be necessary to apply a general insecticide shortly before harvesting.

It is the purpose of this paper to report on an experiment in which several of these insecticides were compared, both in relation to the kill obtained directly following their use, and also on the longevity of the residues of the various materials. The test insect used was the cabbage aphid. No assessments were made of the effect of the insecticides on the various natural enemies of this aphid.

Materials and method

The experiment was carried out during 1951 with cabbage plants growing in a loam soil in eight-inch pots. Before being used in experiments, the plants were sprayed with a nicotine solution to free them of all aphids. Two days later, on 13th June, each plant was infested with 10 mature apterous cabbage aphids which settled down and proceeded to multiply rapidly. On 4th July, when the aphid populations had reached about 500 per plant, the following insecticidal treatments were carried out :—

1. Pestox 3, 0.3 per cent. solution in water, 200 cc. per pot.
2. Pestox 3, 0.3 per cent. solution in water.
3. Parathion, 0.025 per cent. emulsion in water.
4. HETP, 0.1 per cent. solution in water.
5. Gamma BHC, 0.005 per cent. suspension in water.
6. Sprayed with water only (control).

Treatment 1 was a soil application, and in treatments 2-6 the materials were sprayed onto the upper and lower surfaces of the foliage.

The Pestox 3 was a commercial preparation containing mainly schradan (octamethylpyrophosphoramidate) and a triphosphoric homologue of the same series; a description of the material used is given by Hartley *et al.* (1). Both schradan and the homologue are systemic insecticides. In treatment 2 the soil was protected by a cardboard collar and by pads of cotton wool during the spraying. The diluted insecticides used in treatments 2, 3, 4 and 5 were applied as fine mist-like sprays and a complete cover of the upper and lower surfaces was obtained. In the case of treatments 3, 4 and 5, no special precautions were taken to prevent spray-solution from running off the foliage onto the soil in the pots. The small overlapping heart-leaves were not completely wetted so that, with certain treatments, small groups of aphids in the centres of the plants survived the action of the insecticides.

There were 10 single-plant replicates of each treatment and the experiment, which covered the period 13th June to 1st October, 1951, was carried out in a glasshouse. From the time of the original infestation, the population of aphids on each plant was assessed every second or third day (for method, see below). In this way, it was possible to follow the changes in aphid populations following the various treatments.

Two days after the insecticides had been applied, 12 mature apterous cabbage aphids were placed in a group on the upper surface of one leaf of each plant. The fate of each 'inoculum' was followed and the success or otherwise of the colonisation recorded. Similar 'inoculations' were repeated at three to four-day intervals on each plant throughout the period of the experiment. They were discontinued on any plant when two successive inoculations had 'taken', and the aphids had continued to reproduce vigorously.

The plants were also open to infestation by aphids from another source. These were winged viviparous females, which emanated in considerable numbers from the untreated plants in the glasshouse from early June onwards.

The residual action of an insecticide was considered to have ended when the main central aphid colony had achieved a constant rate of increase which was comparable with that of the controls, and when successful colonisation by the inocula had occurred.

Assessment and presentation of results

Changes in insect numbers follow geometrical rather than arithmetical progressions and should be considered accordingly. It is usually more important, therefore, to decide whether there are approximately 8, 16, 32 or 64 aphids per plant than to decide exactly between 28, 29, 30 or 31 individuals. Even when there are relatively large numbers of insects on the plant, it is possible with a little practice to make a good estimate of the order of the numbers present and hence to be able to assign the population to one of a series of categories in geometrical progression. This method has been used to follow the changes in aphid population on cabbage plants in this experiment. The arbitrary progression and the corresponding grade numbers used to classify the population are given in Table I. Geometrical means have been used throughout the calculations.

To check on the accuracy of this method of estimation, a supplementary series of 55 plants, having various levels of aphid population, were graded and the aphids then removed from the plants and counted. The number of plants placed in each category and the mean number of aphids, n , per plant in the various groups is also shown in the table. These observed means were always greater than the expected theoretical values for the grades, especially with the larger populations. The tendency was to place marginal cases into the lower of two grades, thereby underestimating the number of aphids present.

In the experiment itself, the population of aphids on each plant was assigned at each examination to one of the grades. The gradings for the ten plants of each treatment were then translated to the observed mean population values, n , for the respective grades. From these, the mean population of each treatment was derived and the values are plotted in Fig. 1. In order to take into account zero levels of

TABLE I

Classification of aphid populations on supplementary plants based on an approximate geometrical progression, together with errors of assessment of numbers of aphids

Grade No.	Geometric intervals	Expected mean	Observed mean (n)	Total No. of plants counted	No. of plants incorrectly assessed	
					+	—
0	0	0.00	0.00	3	0	0
1	1-4	2.00	2.17	5	0	0
2	5-11	7.42	7.84	7	0	1
3	12-33	19.9	20.6	7	0	0
4	34-100	58.3	65.6	7	0	1
5	101-300	174	217	7	0	1
6	301-900	520	734	7	0	2
7	901-2,700	1,560	2,150	7	0	2
8	2,701-8,100	4,690	6,240	5	0	2
Total				55	0	9

population the device described by Williams (2) was used to calculate the mean treatment values. The aphid populations have been plotted on a logarithmic scale in Fig. 1 in order to facilitate the interpretation of the results at low levels of population without using an excessively long ordinate.

Maximum and minimum temperatures inside the glasshouse were recorded twice daily at 0800 and 1600 hours G.M.T. and the daily mean temperature is shown above the population curves in the figure.

Results

The results shown graphically in Fig. 1 refer only to the heart-colony populations of aphids. The figures for the separate 'inocula', which were placed on the outer leaves of the plant, were not included as they were in general confirmatory of the trends observed in the heart colonies.

Following the initial transference to the plants of ten adult apterae on 13th June, the rate of population increase was irregular until after the first generation or so when the stages of the aphids were sufficiently staggered. Thereafter, a steady geometrical increase in numbers occurred up to the time of treatment on 4th July. On the control plants a pause in the increase in population occurred at the time of treatment. This was most probably due to the removal or disturbance of aphids by the water spray used. Apart from this, the original steady growth rate of the population was maintained and the plants became severely infested, whereupon the assessments were discontinued.

On a second series of ten control plants, set up in early August, the rate of increase of the aphid population was somewhat slower than on the first set of controls. This was probably due to the lower temperatures which prevailed at this time.

The treatment with the shortest residual effects was HETP. The kill of aphids in the centre of the plants was very incomplete and within a few days of treatment the population on the HETP treated plants was rising at a rate comparable to that on the control plants and continued to do so until counts were discontinued a fortnight later.

The BHC treatment showed a strong residual effect for approximately three days, after which the population took an upward trend. Although the kill of aphids in the hearts of the cabbages was more complete than with HETP, small colonies persisted,

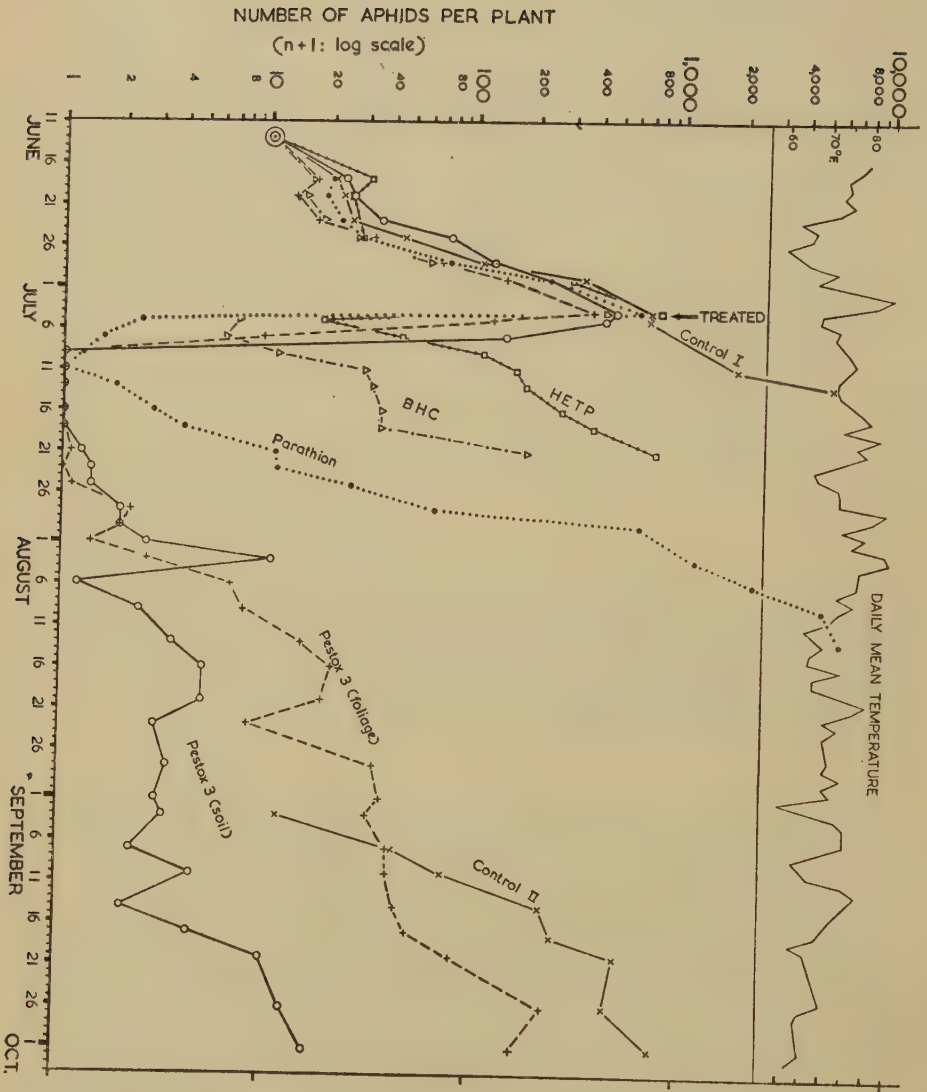


Fig. 1. Graph showing changes in populations of cabbage aphids following treatment with various insecticides.

NOTE: For accurate interpretation, the constant + 1 should be deducted from the indicated numbers of aphids per plant, i.e. a zero level of population is shown as 1 aphid per plant.

having either escaped contact with the insecticide or survived any fumigation effects to which they were subjected. Inoculation with adult aphids on 10th July resulted in immediate colonisation and subsequent inspection showed that they increased steadily, thus confirming the behaviour of the heart colonies.

Parathion caused a very high initial kill but left small heart colonies and numbers of wandering aphids. These declined rapidly in numbers, and seven days after treatment only two very small heart colonies remained. After this time, winged migrants from the other plants in the glasshouse were successful in re-colonising the young central leaves and the aphid population therein proceeded to increase rapidly. By the time observations were discontinued some five weeks later, very high levels of population had been reached.

The parathion residues on the outer leaves persisted for a much longer period and it was not until 21 days after treatment that transferred aphids ('inocula') were able to establish themselves there and increase steadily.

The Pestox 3 used as a foliage spray was more rapid in taking effect than when applied as a soil treatment. Twenty-four hours after application, the foliage spray had produced a marked decline in population, whereas three days were required to show a comparable effect with the soil treatment. It is interesting to note that both methods of application took a similar time, namely five days, to reduce the population to zero and both completely prevented any re-establishment of insects for a further nine days or so. Thereafter, re-colonisation by winged migrants occurred and the populations increased slowly but followed different rates in the two series.

Considerable fluctuations in populations occurred in late July and in August with the systemic treatments. As only small numbers of individuals were concerned, these fluctuations may well have been due to generation effects modified by the presence of the insecticide, and changes in temperature. The trends of the two curves differ appreciably from the recovery curve for the population on the parathion treated plants in late July and early August, and the population curve for the second control in September (the rapid rate of increase of aphids on the parathion treated plants during this period would seem to justify the use of this series as an additional control). It must be concluded that during August and much of September the systemic insecticide in the foliage was acting as a restraining factor on aphid multiplication in both series, and that this residual action was most marked following soil treatment. Unfortunately, it was not possible to carry the experiment to its logical conclusion, and thereby determine when the residues in the central growing leaves of the plant had functionally disappeared.

As with other treatments, groups of twelve aphids were transferred every two to three days from 10th July onwards to the mature outer leaves of the plants. In the early post-treatment period, these died within four to six days, usually without reproducing. On the foliage-treated plants, aphids transferred on 14th September succeeded in reproducing before succumbing to the effects of the insecticide, but the colonies died out over the course of the next ten days. A transference of aphids made on 20th September behaved similarly, showing a rise in population by the 28th, but a sharp decline by 1st October. These observations indicate that the foliage-applied insecticide was still persisting in the mature leaves at the end of the experiment. In the case of soil-treated plants, the transferred aphids showed no signs of increasing until 28th September when the situation appeared to be much the same as that recorded for the foliage-sprayed plants on 14th September. These results indicate that a longer and more potent residual action is to be expected from soil applications of this insecticide.

A discussion of the effects of insecticidal residues on the rate of insect multiplication is given in (3).

DISCUSSION

The persistence of insecticidal residues on foliage depends on a number of factors. Among the most important of these are the physico-chemical properties of the toxicant, its method of formulation, the amount applied and the weather following

application. The rate of plant growth also has an important bearing on the apparent reduction of residues (4). It must not be assumed that the cessation of insecticidal action necessarily implies a complete disappearance of the residues. These may still persist in appreciable though sub-lethal amounts which have little or no effect on the insect.

As the experiment was carried out in a glasshouse it is not possible to translate the results directly to field conditions. An examination of the daily mean temperatures as given in Fig. 1 shows that they are much higher than would have been found in the field. High temperatures tend to induce more rapid volatilisation of insecticides and their residual effects, therefore, could be expected to have lasted a shorter time under glasshouse conditions than in the field. This would apply especially to BHC and parathion, both of which are appreciably volatile. It is unlikely that the performance of HETP would be greatly affected, however, since this compound is almost completely hydrolysed in 24 hours (5), and its effects are usually considered to be complete within a few hours of treatment (6). Dicker (7) has pointed out the danger of translating results with systemic compounds from glasshouse to field conditions. The influence of environment on plant growth can materially alter the behaviour of a systemic insecticide making it difficult to relate the two situations.

No residual effects were shown by the HETP treatment in this experiment. From its known properties (5, 6, 8) it is likely that it produced no further kill after 24 hours. As HETP is relatively non-selective, killing both pests and natural enemies, and has little residual action, rapid re-infestation of the treated crop may occur and thereby necessitate repeated spraying to maintain a satisfactory level of pest control.

The BHC treatment showed a strong residual action for three days in this experiment; under lower temperature conditions in the field, it would probably have lasted longer, depending on the amount (concentration and dose) applied (9). When allowances are made for the different experimental conditions, the results agree with previous work on BHC residues (10, 11). Because of the danger of tainting the crop, BHC sprays are not normally recommended for green vegetable crops which are approaching maturity.

The almost complete kill obtained with parathion was most probably due to a powerful contact action combined with its apparent ability to be translocated through the lamina of the leaf (7, 12). There appears to be no conclusive evidence of a true systemic action by parathion (7, 13, 14), but absorption of its vapour by various parts of the plant cannot be precluded (15). Both biological and chemical evidence are in good agreement over the question of the persistence of parathion residues on plant foliage, and most records show that residues from spray applications are very slight (0.1–0.3 ppm.) ten days after spraying (14, 15). In the case of lettuce, Smith *et al.* (13) found excessive residues (2.0 ppm.) present after 20 days and concluded that parathion was unsuitable for this type of crop except for use during the early stages of growth. However, Sloan *et al.* (16) showed that with a hearted type of Iceberg lettuce, the main residues occur on the older, lower, outside leaves which are usually not cut and the highest parathion residue which they recorded on marketable heads was one of 0.14 ppm. following a spray four days before harvest. The residues on the cabbage used in this experiment, as judged by aphid survival, appear to have paralleled those on the Iceberg lettuces referred to, in that the aphids were able to persist and reproduce in the hearts ten days after treatment, but could not establish themselves on the outer leaves until some 21 days had elapsed. Thus it would appear unwise to treat cabbages with parathion within three weeks of marketing, as some of the foliage harvested is liable to carry appreciable residues.

Parathion is one of the most potent of modern insecticides and shows little discrimination between pestilent and beneficial insects. If used excessively in the field, the population balance may be adversely affected, thus enabling the pest to multiply much more rapidly than had no treatment been carried out. Ripper *et al.* (17) indicate that three sprays with parathion were necessary to limit a cabbage aphid population during a period of seven weeks as compared with one application of the systemic material, Pestox 3. In its effect on the biological balance, parathion appears to be more disturbing than HETP.

In this experiment, Pestox 3 used both as a foliage spray and as a soil application gave the most complete kills and showed the longest residual actions of any of the materials. The considerable longevity of the residues in the foliage is a definite advantage when considered from the view-point of insect control but a disadvantage from the view-point of possible residues in the harvested crop.

Many factors appear to affect both the rate of absorption of the systemic into the plant and the persistence of residues within it. The quantity of the insecticide absorbed from a foliage spray varies with the state of growth of the plant and with the prevailing meteorological conditions during the 48 hours or so immediately following the application. When plant growth is almost at a standstill, as under near-dormant conditions, the rate of absorption is slowed up (7, 18) and a large amount of the toxicant can be lost by evaporation before it is absorbed, especially in an agitated atmosphere (18). If it can be assumed that there is a threshold concentration in the plant below which the systemic shows negligible restraining properties on the insect population, then, from a given quantity applied, the relative amount absorbed will be important in determining the longevity of its effect, though fluctuations occur in the rate of breakdown of the material in the plant. Hence, the conditions governing degree of absorption into the plant will affect the ultimate longevity of the residues from an initial fixed quantity applied. Both translocation and rate of breakdown within the plant seem to be governed by factors affecting general plant activity (18), so that these also must affect persistence of the residues. The toxicity of the absorbed material appears to be largely, if not wholly, due to the production in the early stages of breakdown of a definite metabolite, the exact identity of which appears to be unknown (19, 20). The ability of the plant to produce this metabolite will determine its systemic activity at any one time and Casida *et al.* (19) have shown, for example, that the phosphorus content of the plant has an influence in this respect.

As might be expected, the seasonal influence on plant growth is important in determining the rate of metabolic breakdown and consequent systemic activity. Dicker (7) has demonstrated an increased persistence and a reduced systemic effect on strawberries treated during the early winter period (November to January) and Heath *et al.* (18) have shown a seasonal slowing up of the rate of decomposition of schradan on strawberries; those sprayed in May lost 90 per cent. in 23 days, in July, 90 per cent. in 30 days, and in August to September, 90 per cent. in 42 days. The same authors state that Brussels sprouts treated in mid-October showed little loss of systemic material by the beginning of January and they suggest a possible correlation between rate of decomposition and incident solar radiation. They also indicate that the rate of loss is remarkably independent of variation of plant species.

The application of schradan-containing materials to the soil seems to result in a slower initial action and a longer persistence of residual systemic action, as shown by the results of this experiment and also by previous findings (21). It has also been shown that the phosphorus available in the soil affected the uptake of the insecticide by pea plant roots (19) and that for broad bean plants absorption was more rapid from sand than from soil (22). Soil type and conditions, therefore, play a part in the performance of soil-applied materials. Bennett reported that a concentration of schradan in the soil of 200 ppm. kept cauliflowers free from infestation by cabbage aphids for three to four weeks (23). This was considerably longer than the time for which the plants were kept completely free from aphids in the present experiment, although there followed a period of nearly two months during which the population was maintained at very low levels. In this experiment the concentration of schradan in the soil was approximately 160 ppm. Compared with foliage sprays, soil treatment appears to be the less economic form of application and there is a greater uncertainty as to the length of time required before the material used in this way becomes exhausted.

From the information available, therefore, the performance of materials containing schradan depends on a number of complicating factors, many of which are not fully understood. The possibility that residues may only partially disappear before the onset of plant dormancy must be recognised, as this could lead to toxic materials

being present in the plant when marketed. Such a situation could arise following the treatment of autumn infestations of the cabbage aphid on brassicae.

Unlike parathion, schradan is selective in action, being highly toxic to many groups of sucking insects, particularly aphids, but causing little damage to their parasites and predators. This is a characteristic of great potential value, since after treatment the unharmed beneficial insects are able to prey upon the surviving pest population and upon new immigrants and therefore delay or prevent a rapid rebuilding of the pest population. High specificity and long residual action are in general very desirable properties for an insecticide. When used in the field, however, considerable care must be taken, by a judicious choice of dosage, time and method of application, to ensure that toxic residues in the marketed produce do not occur or are at negligible levels.

SUMMARY

1. A comparison has been made of the relative effectiveness and persistence of HETP, BHC and parathion applied as foliage sprays and of Pestox 3 applied to the soil and to the foliage. The test insect used was the cabbage aphid, raised on cabbage plants growing in pots in the glasshouse.

2. Both the HETP and BHC sprays gave high initial kills of the aphids which were wetted by the spray but small colonies among the heart leaves were not killed. The HETP showed a short residual action and did not affect the aphid population for more than one day, whilst the BHC showed a strong residual action for three days after spraying.

3. The aphids suffered a very high initial mortality following treatment with parathion. They were able to persist and multiply in the hearts of the plants after seven days but not on the outer leaves until three weeks had elapsed after spraying.

4. When Pestox 3 was sprayed on to the cabbage foliage it affected the aphids more rapidly than when it was applied to the soil. This difference disappeared after five days, when, with both treatments, the aphid population simultaneously reached a zero level which was maintained for a further nine days.

5. Two weeks after spraying, small numbers of aphids appeared on the heart leaves of the plants in both series of Pestox 3 treatments. During the next two months, the aphids in the hearts of the treated plants increased in numbers at a much slower rate than did those on the untreated series, indicating that the residues of the insecticide were restraining multiplication of the aphid population throughout this period. The effect was more marked for the soil treatment than for the foliage spray.

6. For a period of some three months, aphids were unable to colonise the outer leaves of plants which had received treatment with Pestox 3. This indicated the very prolonged residual action of this insecticide in these leaves under the conditions of the experiment.

7. The effects of certain factors on the rate of absorption and on the persistence of schradan-containing materials in the plant are discussed and the possibility of toxic residues remaining in the harvested crop are noted.

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RATES OF CHANGE IN INSECT POPULATIONS FOR DETERMINING THE LONGEVITY OF INSECTICIDAL ACTION

By G. A. WHEATLEY

With the advent of modern insecticides, many of which are very toxic to warm-blooded animals as well as to insects, it has become increasingly important to know the length of persistence of the residues on or in treated crops. An indication of the minimum time for which residues persist can often be obtained by observing the longevity of insecticidal action, although it should be borne in mind that cessation of activity may not necessarily imply a complete disappearance of the residues.

The usual method of assessing the effectiveness of an insecticide in the glasshouse or the field is to compare at intervals the numbers of insects in treated and untreated populations, and to express the results as a percentage reduction in population. There is a decrease in the reduction in population as the insecticide loses its effect, but when this method of assessment is used, it is difficult to estimate the point at which the insecticide ceases to be active. If, instead of this method, the relative rates of change in numbers of the insects were to be used, as discussed in general terms below and explained schematically in Fig. 1, a better estimate of the end-point of insecticidal activity could be obtained. Such a method of approach is particularly applicable to those insects having a short life cycle which enables the effects of the residues to be reflected rapidly in the net rate of multiplication of the insect.

The unrestricted multiplication of a living organism is usually considered to result in an exponential increase in population with respect to time at least until very high levels of population are reached. Williams (1) has pointed out that the changes which occur in the numbers of an insect population usually follow a geometric progression and that the simple arithmetical treatment of such data can be quite misleading; for example, means should be derived geometrically. When the logarithms of the numbers (or the $n + 1$ transformation (1)) are plotted against time for a population increasing under uniform conditions, the trend of the resulting curve would be expected to approach linearity throughout (Fig. 1a). Reference to the graph of Wright and Wheatley (2) shows that a close agreement with this hypothesis was obtained with *Brevicoryne brassicae* L. reproducing on cabbage plants under glass-house conditions, even though only an approximate method of estimating the population levels was used.

In the early stages of an infestation, the individual insects are usually all in a similar state of development and the slope of the resulting curve should be irregular (Fig. 1b) until the generations become staggered, after which a steady trend should result (cf. the increases in population at the beginning of the cabbage aphid experiment (2) mentioned above). If necessary, it should be possible to overcome this generation effect by infesting the plants at the beginning of an experiment with insects at all stages of development.

Under optimal conditions, the rate of population increase is greatest and the slope of the population growth curve should then be at a maximum since it is a direct measure of the rate of multiplication of the population (Fig. 1a). The rise in numbers would proceed at a slower rate under all other (non-optimal) conditions so that the slope of the resulting curve would be flatter. A non-optimal condition, such as a fixed temperature limitation or a constant mortality factor, places on the population a constant degree of restraint which would alter the slope of the line but would not affect the linearity of the relationship, as indicated in Fig. 1a.

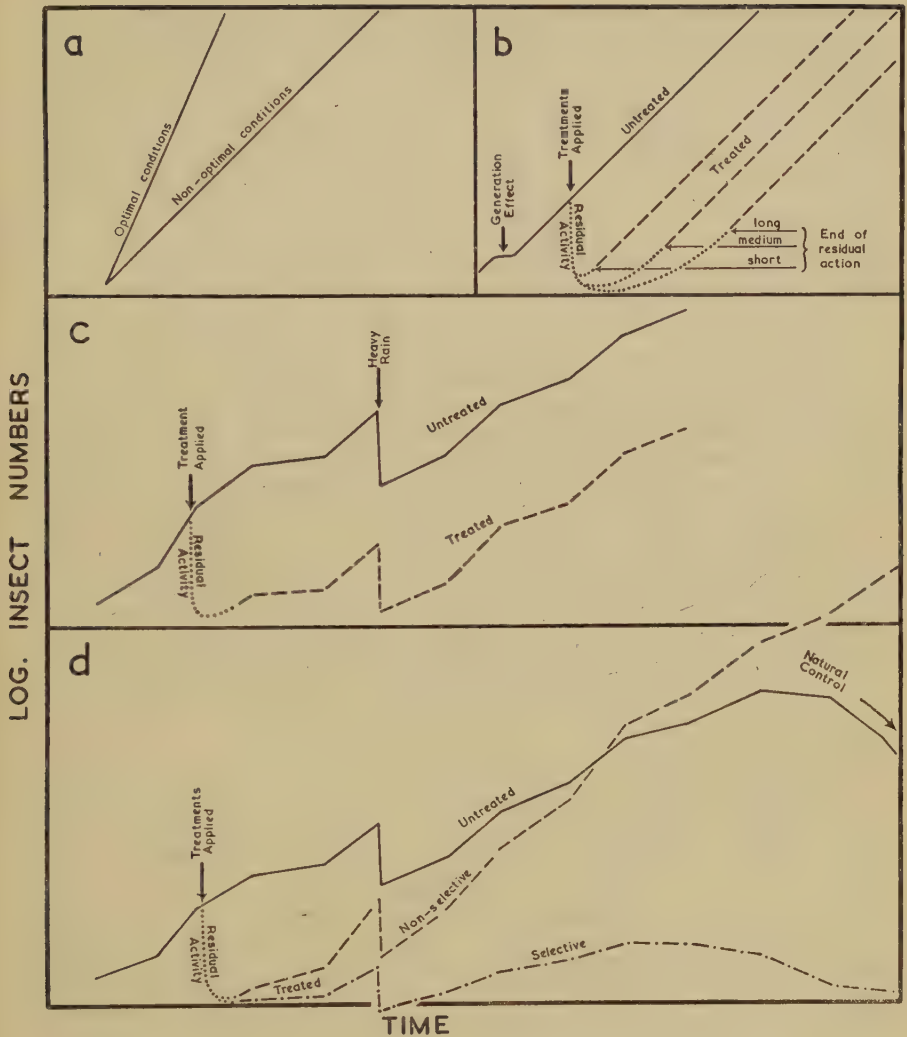


Fig. 1. Diagrammatic illustrations of hypothetical ways in which various factors would affect the regression of log. insect numbers against time.

- Trends of population increase in uniform environments; rate of increase maximum under optimal conditions.
- Changes in populations resulting from the application of three insecticides having different degrees of persistence, conditions being otherwise uniform.
- Probable trends in log-numbers of a field population due solely to variations in physical factors such as temperature, rain, etc. These changes reflect similarly in treated and untreated populations and can thus be distinguished from treatment effects.
- As for (c) above, but with consideration given to possible effects produced by natural enemies following the use of selective and non-selective insecticides of relatively short persistence. The indicated trend of this population treated with the non-selective insecticide is typical of what might be expected; the behaviour shown for the population treated with the selective material is only one of many which could occur.

We may now consider the effect of applying an insecticide to a steadily increasing insect population (Fig. 1b), under uniform conditions of environment. The effect of an insecticide is to produce a variable restraint which would be severe at first, producing a rapid reduction (negative rate of increase) in insect numbers. As potency decreases with time, the restraint on the population is gradually removed. A point is reached when the reproductive rate of the insects exceeds the death rate produced by the insecticide and the numbers should again begin to rise at an increasing rate. However, a rate of increase equal to that of the untreated control population would not be reached until the last effects of the toxicant had worn off. At this point, the curve for the treated population should again assume linearity and be parallel to that of the control, other factors being equal. Thus, a good estimation of the longevity of insecticidal action should be obtainable by noting the point at which the treated population begins to multiply at the same rate as the untreated population as shown by the parallelism of the plotted curves.

The cabbage aphid experiment (2) showed excellent agreement with the hypothesis outlined above as applied to the restricted conditions of the glasshouse. There is a very close parallelism between the population recovery curves of the HETP, BHC and parathion treatments with that of the controls. The markedly flatter trends of the two curves representing the Pestox 3 treated plants, as compared with the rest, are obvious and they reveal the long-term action of the material. It is probable that the slope of these two curves also equalled that of the second control series towards the end of the experiment and, had it been possible to carry on the observations for a longer period, it would have been easier to determine the point at which the insecticidal action ceased. It is noteworthy that the rate of multiplication of the aphids on the second control series was decreasing steadily towards the end of the experiment due to the lower daily mean temperatures which occurred late in the season. The irregularities in the rates of population recovery for the two systemic treatments appear to be periodic generation effects, artificially produced by the disparity of kill caused by the different susceptibilities of mature and immature aphids to the same dose of residual toxicant.

The foregoing discussion relates to conditions, such as are found in the laboratory or the glasshouse, where the physical environment is relatively uniform and biological factors, which normally tend to limit population increase, are operative only to a negligible degree. The situation in the field is much more complex, however, as it is necessary to take into account wide variations in weather conditions, and also the interaction between an insect and its natural enemies. Therefore, changes in numbers of insects in an untreated field population usually proceed at an irregular rate, as they are subjected to unpredictable fluctuations of the environment. Thus, plotted data would not necessarily result in straight line relationships (Fig. 1c, d). The basic phenomena should still operate, however, but a more careful interpretation of the data would be necessary using information obtained from general observations which would, of course, be specific to each experiment. Prevailing physical conditions are usually common to the whole experimental area and, thus, should be reflected similarly in the changes which occur in both treated and untreated populations (Fig. 1c).

The main overall effects from an insecticidal application result from the initial kill, the persistence of active residues and the degree of selectivity between the pest and its natural enemies. The length of residual action would determine the time taken for a treated population to begin increasing at a steady rate (Fig. 1b) whilst the effects of its selectivity would be expressed by the rate of this steady multiplication relative to that of the controls (Fig. 1d). The degree of selectivity will not be fully discernible until the residual action has ceased. In general, a non-selective insecticide should produce a greater rate of increase than that of the controls since it removes the restraint normally imposed by the natural enemies. With a selective insecticide, however, the rate of increase should be much slower than that of the controls. Difficulties in interpretation may arise with an insecticide which has a very long residual action, such as schradan, when it may not prove possible to distinguish in the field between

selectivity and longevity of action without detailed supplementary observations, especially on the effect of the insecticide on natural enemies.

It would seem that by this method of approach, considerably more information could be obtained on residual action than by considering merely absolute levels of populations at infrequent time intervals after treatment, the additional requirement to current practice being that data should be taken at more frequent intervals and over a longer period than is usual. The method has a particular application in the study of long-term effects following the use of insecticides. Where necessary, the transformed regression lines lend themselves to a simple statistical analysis.

SUMMARY

1. A discussion is given of some general implications involved when use is made of the rate of changes in numbers of an insect population to determine the residual action of an insecticide in the laboratory, the glasshouse or in the field.

2. Under laboratory or glasshouse conditions, the residual action of an insecticide can be considered to have ceased when both treated and control populations are increasing at the same rate. In the field, after the residual action has ceased, the general behaviour and overall rate of multiplication of a treated population will depend on the selective properties of the insecticide.

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IRRIGATION EXPERIMENTS WITH RADISHES

By E. J. WINTER

Two experiments were carried out on Bungakow Field during the late summer and autumn of 1952 to examine the effect of certain systems of watering radishes, and incidentally, to gain experience in the operation of a new precision irrigation apparatus.

Cultural details

The soil was a sandy loam overlying Keuper marl, and was very suitable for irrigation work. After the previous crop of summer lettuce had been harvested, the soil was rototilled to a depth of $2\frac{1}{2}$ inches and one ounce of dried blood per square yard was broadcast and rototilled in. Scarlet Globe radish seed was then sown in drills 3 inches apart and $\frac{1}{2}$ -inch deep at the rate of 1 gram per metre of drill (approximately 1 ounce per 31 yards). The seed for each separate metre of drill was measured out and sown by hand as evenly as possible. Care was taken to consolidate the soil evenly after closing the drills.

Method of Irrigation

Hitherto most experimenters on overhead irrigation have relied on adaptations of commercial spraylines or rainers. Christiansen (1), Korven (2) and others demonstrated that wind caused large errors in the distribution of water by rotary rainers. Penman (3) has mentioned the inconvenience of having to await calm conditions before using spraylines to apply water in his irrigation experiments on sugar beet. Even in calm conditions Christiansen found that spray lines and rotary rainers failed to spread the water evenly over the wetted area.

In the experiments described below, the water was applied by means of an apparatus which was designed jointly by Mr. G. Bean (National Institute of Agricultural Engineering) and the author. This apparatus (Fig. 1) consisted of a travelling boom carrying a row of modified Cameron Trickle Irrigation nozzles spaced one inch apart. Various devices were incorporated to control the supply of water to the boom through a hose at one gallon per minute, and four feet head of pressure measured at the nozzles. A stationary electric winch towed the boom slowly backwards and forwards across the plots on simple elevated rails, until the required volume of water had been applied. The apparatus will be described in detail elsewhere (4).

Measurements made by Best (5) indicated that in natural rainstorms of intensity one-eighth inch per hour, 70 per cent. of the water was in drops of diameter between 0.5 and 2 mm. All the water applied by the apparatus was in the form of drops about 0.5 mm diameter, unaccompanied by spray of any kind. Evaporation losses from such large drops, falling only about two feet, could be ignored, while the horizontal deflection produced by a 10 m.p.h. wind was only about two inches at ground level.

The rainer was capable of applying accurately the required quantities of water at a controlled rate to plots of any dimensions up to 16 feet by 60 feet. The greatest variation in volume of water applied to any two 9-inch diameter circles within a plot was ± 2 per cent.

Plot size

In Experiment 1 the plots were two feet wide by ten feet long, with paths one foot wide between plots. Difficulty was experienced in causing the boom to traverse accurately a run of only two feet, and in Experiment 2 the width of the plots was

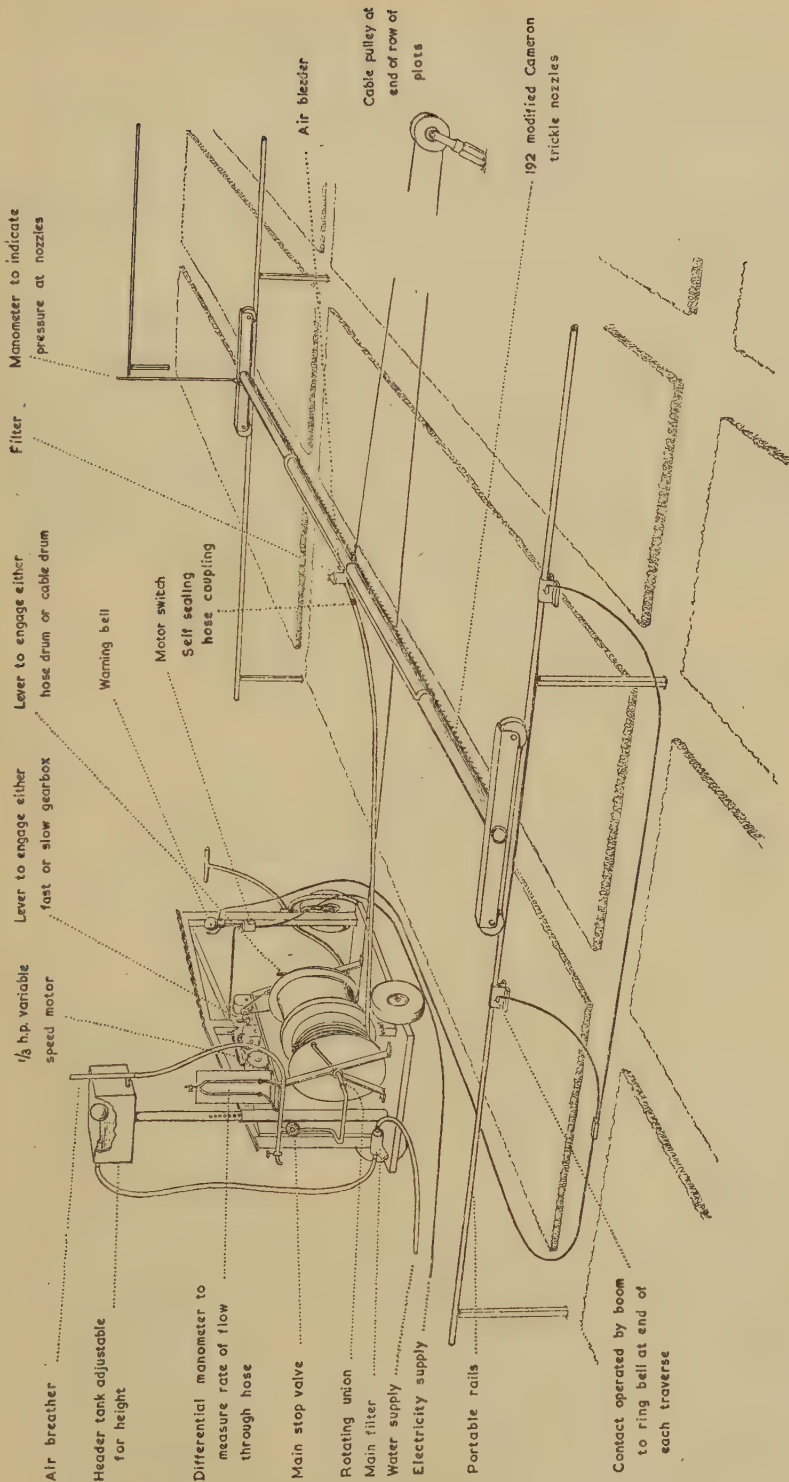


Fig 1 Apparatus for evenly distributing accurately measured quantities of water over experimental plots. Designed jointly by G.Bean (N.I.A.E.) and E.J.Winter (N.V.R.S.)

increased to five feet. Further tests showed that this was the minimum traverse which could be dealt with satisfactorily by the machine in the form described.

Irrigation treatments

Similar treatments were applied in both experiments.

1. Control—no irrigation.
2. Water applied immediately after sowing.
3. Water applied one week after sowing, and again at approximately weekly intervals thereafter, weather permitting.
4. Treatments 2 and 3 combined.

The quantity of water applied at every irrigation was 0.6 inch in Experiment 1 and 0.4 inch in Experiment 2. Irrigation was carried out as planned even if light rain was falling at the time, but it was sometimes found that a shower brought the surface soil temporarily to field capacity so that if irrigation had been continued run-off would have occurred. On such occasions irrigation had to be interrupted. When irrigating only one plot at a time, in unsettled weather, interruptions could prevent the completion of a block within a reasonable period. Consideration is now being given to a method of irrigating a whole block at one time by operating a separate boom for each plot from a single winch. Such a machine could be stopped during showers without affecting the uniformity of treatment of plots within the block.

RESULTS

At intervals during the growing period samples were harvested by taking transects $\frac{1}{2}$ -metre wide across each plot.

TABLE I

Experiment 2

Mean number of plants per metre of row (Figures in heavy type)
Running total of irrigation water applied (Figures in light type)

Treatment	Number of days after sowing				
	32	42	49	60	77
1. Control	32 0"	51 0"	61 0"	69 0"	75 0"
2. 0.4" applied once after sowing ..	52 0.4"	80 0.4"	91 0.4"	86 0.4"	105 0.4"
3. 0.4" applied at approximately weekly intervals, weather permitting	52 0.8"	83 1.6"	92 1.6"	96 1.6"	86 1.6"
4. 2 and 3 combined ..	55 1.2"	79 2.0"	88 2.0"	90 2.0"	95 2.0"
Difference required for significance ($P=0.05$)	7.0	11.0	23.0	17.0	8.1
Standard error as percentage of general mean	9.4	9.1	17.3	12.2	5.6

Plant population

In Experiment 1 the number of plants per metre of row did not differ significantly between treatments, though there were indications of a denser plant population on irrigated plots. In Experiment 2, the number of plants on control plots increased more slowly than on irrigated plots, where the population approached its maximum about seven weeks after sowing (Table I). Throughout the experiment the population on control plots was significantly lower than that on irrigated plots. There were no significant differences in population on plots which received different irrigation treatments. The larger number of plants on irrigated plots was found to be mainly due to an increase in number of plants with 'bulbs' less than $\frac{1}{2}$ -inch in diameter (Table II).

Bulbs

The edible part of a radish is in fact the swollen root, but for the sake of brevity, it will be referred to here by the more commonly used term, 'bulb'.

The bulbs were divided into 'large' and 'small' categories by means of a sieve with round holes, $\frac{1}{2}$ -inch in diameter.

In Experiment 1 there was a significant increase in the number of small bulbs on those plots which received most water, *i.e.*, treatment 4, but the corresponding slight increase in number of large bulbs was not significant. Weekly watering (treatments 3 and 4) significantly and substantially increased the weight of large bulbs (Table II).

TABLE II

Typical results obtained at one harvesting of Experiment 1, 35 days after sowing

Treatment	Total irrigation inches	Bulbs				Leaves
		Mean No. per metre of row		Mean fresh wt. per metre of row in gm.		Mean fresh wt. per metre of row in gm.
		small	large	small	large	
1. Control	0	18	40	9	152	129
2. Watered once after sowing ..	0.6	20	39	8	171	136
3. Watered at approx. weekly intervals ..	2.4	22	39	10	238	203
4. 2 and 3 combined	3.0	32	45	12	197	209
Difference required for significance (P=0.05)	—	14	14	8	43	48
Standard Error as percentage of general mean ..	—	40.5	18.3	50.2	14.2	17.7

TABLE III

Typical results obtained at one harvesting of Experiment 2

Treatment	Total irrigation inches	Bulbs				Leaves	Mean dimensions largest leaf on each plant in a random sample		
		Mean No. per metre of row		Mean fresh wt. per metre of row in gm.		Mean fresh wt. per metre of row in gm.	Area sq. cm.	Length of lamina mm.	Length of petiole mm.
		small	large	small	large				
1. Control ..	0	15	46	7	140	93	9.2	51	48
2. Watered once after sowing ..	0.4	34	56	14	118	136	11.3	60	66
3. Watered at approx. weekly intervals ..	1.6	50	42	20	110	121	9.8	56	55
4. 2 and 3 combined ..	2.0	34	54	14	160	145	13.2	65	73
Difference required for significance (P=0.05) ..	—	17	9	5	40	29	2.1	5	4
Standard error as percentage of general mean ..	—	34.4	10.9	23.6	17.2	14.4	12.2	5.2	4.4

In Experiment 2, irrigation with 0.4 inch of water after sowing (treatments 2 and 4) significantly increased the number of large bulbs but not their total weight (Table III). The weight of small bulbs was greater on the weekly watered plots (treatment 3) than on the other irrigated plots. The weight of large bulbs was greater on plots which received most water (treatment 4) than on plots which received either of the other two irrigated treatments. All the irrigation treatments significantly increased the number and weight of small bulbs as compared with the control.

Leaves

In Experiment 1, weekly irrigation (treatments 3 and 4) significantly increased the total weight of leaves per metre of row, as compared with the controls and with the single post-sowing irrigation (Table II). Leaf size and number of leaves per plant were not determined in this experiment.

In Experiment 2, all the irrigation treatments increased the total weight of leaves (Table III). The increase was just not significant in treatment 3. The effects of weekly watering (treatment 3) and of watering once immediately after sowing (treatment 2) appeared to be to some extent cumulative. All these effects persisted until the final harvest eleven weeks after sowing, in spite of rain which prevented any irrigation after the sixth week.

Similar results were obtained for size of leaves, as indicated by the area, length of lamina, and length of petiole of the largest leaf on each plant in random samples.

The number of leaves per plant (Table IV) did not differ between irrigated treatments, but at the seventh and ninth weeks the controls had significantly more leaves than irrigated plants. The mean difference was, however, less than half a leaf. During the fifth and sixth weeks the average number of leaves per plant in all treatments rose from about 2.75 to about 4.75, and thereafter remained more or less constant until the experiment was stopped at the end of eleven weeks.

TABLE IV
Mean number of leaves per plant—Experiment 2

Days after sowing	32	42	48	61	77
1. Control	2.61	4.48	5.08	5.27	4.69
2. Watered once after sowing ..	3.05	4.95	4.70	4.87	4.34
3. Watered at weekly intervals ..	2.58	4.48	4.88	4.90	4.55
4. 2 and 3 combined	2.92	4.41	4.47	4.80	4.51
Difference required for significance ($P=0.05$)	0.45	0.81	0.30	0.30	0.42
Standard Error as percentage of general mean	10	11	4	3.8	5.8

DISCUSSION

Fig. 2 shows the rainfall during the course of the two experiments and the irrigations which were carried out in the various treatments. While Experiment 1 was in progress, the weather was fine and dry except for two heavy rainstorms. In one of these, which occurred three days after sowing, nearly three-quarters of an inch of rain fell. This masked the effect of the single post-sowing irrigation (treatment 2) on the crop, but weekly watering (treatments 3 and 4) during the dry period increased the weight of both large bulbs and leaves. Weekly watering did not increase the number of bulbs because the heavy post-sowing rainstorm had already caused most of the viable seeds to germinate more or less simultaneously in all treatments.

During the first six weeks of Experiment 2 the weather was mainly fair with a few light showers. Thereafter conditions deteriorated and there was a considerable amount of rain during the remainder of the Experiment. The single post-sowing irrigation during the dry period (treatment 2) induced earlier establishment and increased the plant population (Table I). Repeated weekly irrigation (treatments 3 and 4) had no further effect on population and it was apparent that the first irrigation had been sufficient to cause all viable seeds to germinate. This single irrigation also increased the number of large bulbs (Table II), but as measurements showed no corresponding increase in total weight or density, the individual bulbs must have been smaller than in the control plots. Repeated irrigation commencing a week after sowing (treatment 3) tended to increase the number and weight of small bulbs at the expense of the large bulbs, as compared with watering after sowing plus weekly watering (treatment 4).

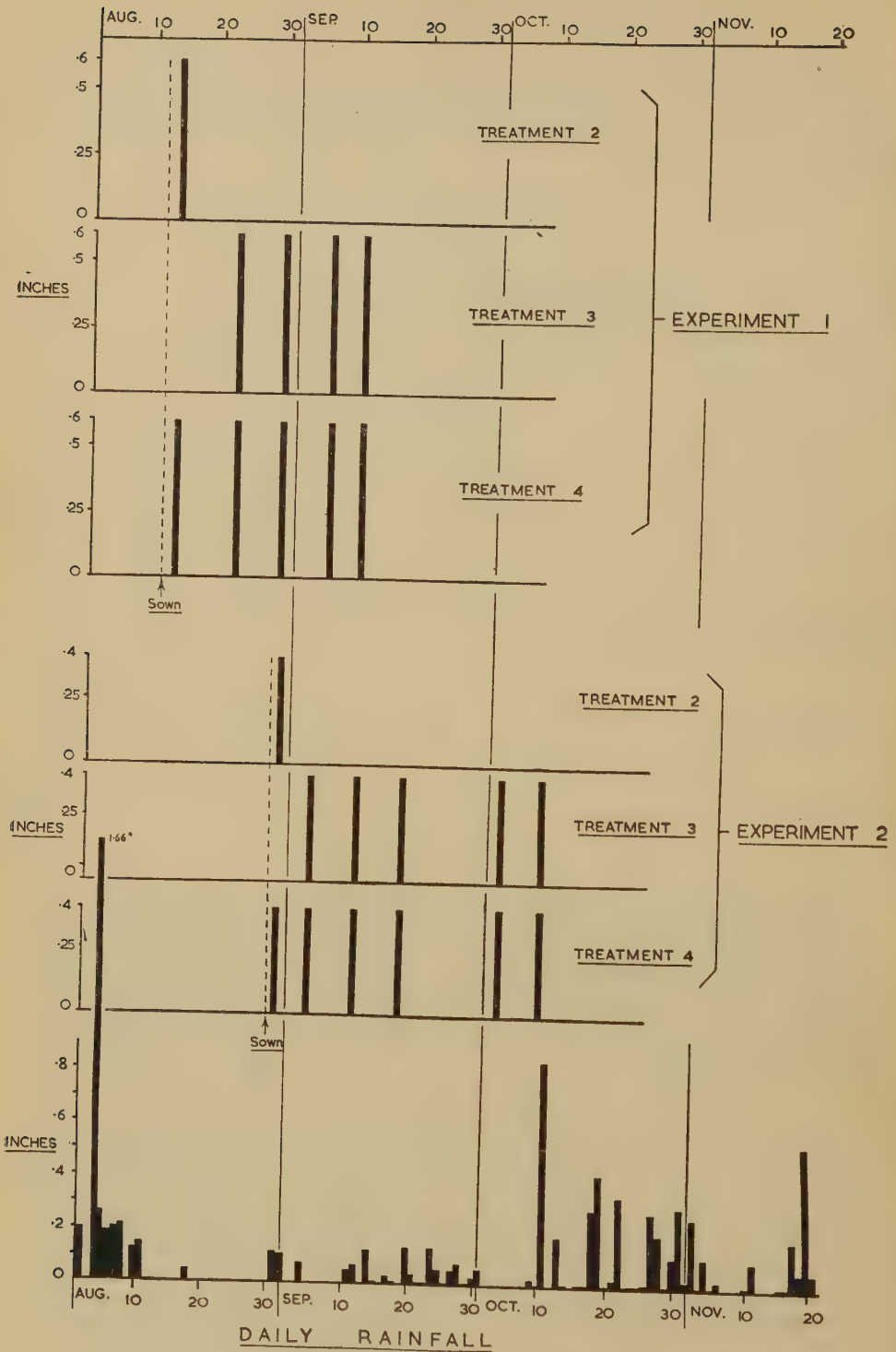


FIG. 2 QUANTITIES OF WATER RECEIVED BY THE VARIOUS PLOTS.

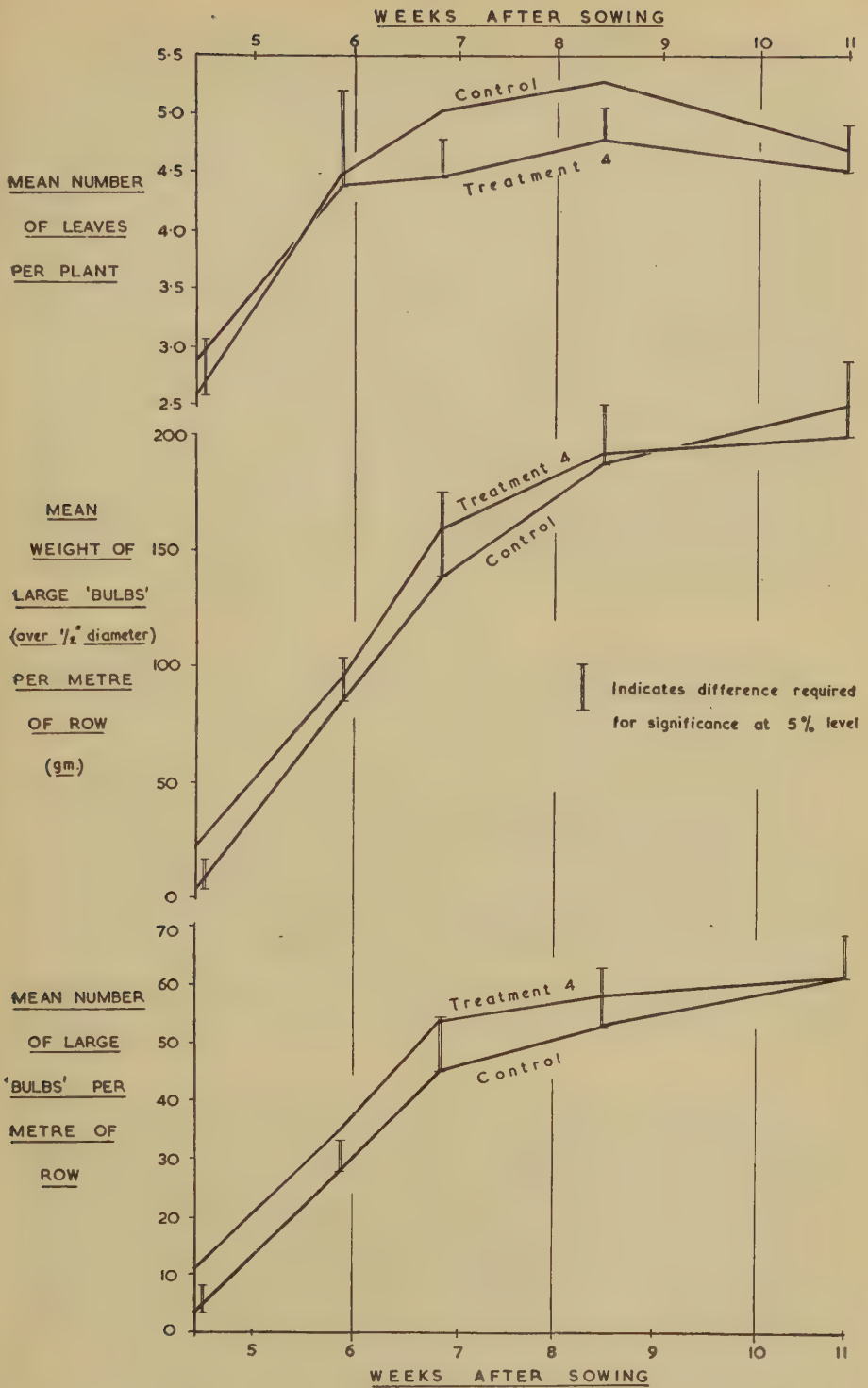


FIG. 3 GROWTH RATES IN EXPERIMENT 2

Consideration of the total quantities of water (*i.e.*, rain plus irrigation—Fig. 2) received by the various plots in these experiments, indicated that about $\frac{1}{2}$ -inch immediately after sowing was sufficient for satisfactory germination (Experiment 2) and that no increase in population or in speed of establishment was achieved by adding more than this quantity of water (Experiment 1). During the growth of the crop, a total of about $\frac{1}{2}$ -inch of water per week seemed to be necessary for the production of a reasonable yield. No attempt was made to establish the optimum quantity of water for radish production, but it is noteworthy that all the irrigation treatments increased the weight of unsaleable bulbs and leaves, thus supporting the growers' belief that excessive watering of radishes makes them 'run to leaf'.

Figure 3 shows results obtained in Experiment 2 for the rate of increase in number and weight of large bulbs, and weight of leaves on the control plots, and on those plots which received most water, *viz.* treatment 4. The rate of increase in each of these quantities began to fall off after the seventh week. These figures indicate that, under the conditions of this experiment, the radishes were ready for harvesting at about the seventh week.

These experiments were carried out in late summer and autumn when the soil moisture deficit was several inches. In spring the effect of watering immediately after sowing might be expected to be similar to that reported here, but the effect of weekly watering during the growing period would probably be less because, in a normal spring, the soil is at or near to field capacity.

SUMMARY

1. Two experiments were carried out in late summer and autumn 1952 to determine the effect upon radishes of the following irrigation treatments :—

Watering immediately after sowing,

Watering at weekly intervals during the growing period,

The above treatments combined.

2. About $\frac{1}{2}$ -inch of water (rain plus irrigation) immediately after sowing, was found to be sufficient for germination and establishment of all viable seeds.

3. Not less than $\frac{1}{2}$ -inch of water weekly (rain plus irrigation) appeared to be necessary for maximum growth under the conditions of the experiment. No attempt was made to establish the optimum quantity of water for maximum crop.

4. Irrigation tended to increase the number of small bulbs and quantity of leaves.

5. A new precision rainer was used successfully in applying the irrigation water accurately and evenly to the experimental plots.

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WEED INVESTIGATIONS

By H. A. ROBERTS

Ecology

Effective utilisation of cultural and chemical methods of weed control depends to a considerable extent upon an understanding of the relation between crop and weed species, and of the ways in which germination and growth are influenced by edaphic and climatic conditions. When land is used for the purpose of vegetable production, certain conditions, such as fertility level and frequency of cultivation, are imposed by the requirements of the crops which are grown. Some weeds are particularly prevalent under these conditions whilst others are not, for reasons which are not always apparent, and information on the factors contributing to this prevalence of certain species is likely to be of value in the selection of appropriate control measures. Data accordingly have been obtained on the duration of life-cycle, rapidity with which ripe seed can be produced and distribution of germination throughout the year for a number of annual weed species. A long-term experiment has been set up to determine the length of the natural dormancy period under field conditions for eleven species, and observations are being made on the effects of drought and frost on the establishment and growth of weed seedlings.

Chemical control

Field experiments have been carried out with various crops to determine the effectiveness of different herbicidal sprays in reducing weed competition during the early stages of crop growth.

In two trials with onions, pre-emergence applications of mineral oils containing pentachlorophenol as a fortifying agent proved promising. The sprays were applied just before the crop appeared above ground and good control was obtained of those weed seedlings which had emerged. The same treatments were used in an experiment with lettuce and again resulted in excellent weed control with no injury to the crop. As the germination of lettuce is relatively rapid, the technique of delayed planting was used, the seedbed being prepared some ten days before sowing so as to allow the weed seeds to germinate and the sprays then applied immediately after sowing.

Trials of various pre-emergence treatments were carried out with peas and red beet, and successful post-emergence applications of DNBP (ammonium 2,4-dinitro-6-secondary butylphenate) were made on peas in an experiment to obtain data on the optimum stage of growth for spraying.

Experience with CMU

CMU, 3-(p-chlorophenyl)-1,1-dimethylurea, is a recently synthesised chemical of high phytotoxicity (1), which has been widely tested in the United States both as a soil sterilant and, at low dose rates, as a residual pre-emergence herbicide for various vegetable and other crops. The principal properties have been described by McCall (2). It is relatively insoluble and entry into the plant appears to be primarily by root absorption, toxic effects not occurring until it has been washed down to the root zone. Rainfall and soil type are of importance in determining the rate and extent to which this occurs, and also affect persistence. The selective action when used as a pre-emergence herbicide may depend on the tolerance of certain crops to low doses, on depth of sowing, or a combination of the two. Spinach and carrots have been cited as crops which are more tolerant than many annual weeds to low doses and with large-seeded crops where the seeds are sown deep, suitable applications may produce a lethal concentration in the surface layers of the soil where the weeds are germinating, while in the zone round the crop seed CMU is absent or present in low concentration only.

Exploratory tests with CMU and several vegetable crops have been made at Wellesbourne during 1952. It was applied at rates of from $\frac{1}{4}$ to 4 lb. in 100 gallons of water per acre, before crop emergence and with a mixed population of seedling annual dicotyledonous weeds present. Excellent control was obtained in all the tests, even a rate of $\frac{1}{2}$ -lb. per acre resulting in more than 80 per cent. kill of such species as *Chenopodium album* (Fat-hen), and *Stellaria media* (Chickweed). Marked specific differences were noted: *Fumaria officinalis* (Fumitory) flourished on all treated plots and *Veronica hederifolia* (Ivy-leaved Speedwell) also appeared to be relatively tolerant.

Observations on the crops confirmed the great importance of rainfall in the action of CMU. In the weeks following an application to onions there was heavy rain, and 1 lb. per acre resulted in almost complete elimination of the crop while $\frac{1}{2}$ -lb. per acre caused 47 per cent. reduction in plant stand. Similar treatments in another trial later in the season were followed by a period of dry weather lasting some weeks, and here there were no injurious effects on the crop until eventually an appreciable amount of rain did fall, and then some leaf tip die-back was observed on plots treated with the higher rate. Tests run concurrently with peas and red beet indicated that these crops were tolerant to rates of up to $\frac{1}{2}$ -lb. per acre.

It was thought worth while to include these notes in this Report because little data is available on the behaviour of CMU under British conditions. The preliminary tests described were, however, very limited, and it is evident that much further work is required before an estimate of the value of CMU as a selective herbicide can be arrived at. Investigation of crop tolerance and persistence in soil under different conditions will be particularly necessary.

Other work

Assistance was given in the planning and execution of a series of herbicide trials with vegetable crops carried out by the Agricultural Research Council Unit of Experimental Agronomy in co-operation with the N.A.A.S. Experimental Horticulture Station, Luddington.

SUMMARY

1. Studies on the ecology of important weeds of vegetable crops have been initiated in order to provide a basis for the application of control measures.
2. Trials of various herbicides were carried out with onions, peas, lettuce and red beet to determine their effectiveness in controlling weeds during the early stages of crop growth.
3. A preliminary investigation was made into the use of a recently described chemical (CMU) as a pre-emergence herbicide for certain vegetable crops.

REFERENCES

- (1) BUCHA, H. C. and TODD, C. W. (1951). 3-(p-chlorophenyl)-1,1-dimethylurea—a new herbicide. *Science* **114**, 493-4.
- (2) McCALL, G. L. (1952). "CMU"; new herbicide. *Agric. Chem.* **7** (5), 40-2, 127 129.

STATISTICS REPORT

By J. A. NELDER

The usual assistance has been given to members of the staff of the N.V.R.S. in the design and analysis of experiments, and in the absence of a Plant Physiologist and Soil Chemist on the Station, general supervision has been exercised over two experiments, one concerned with lettuce under Dutch lights and the other with the effects of the new soil-conditioner 'Krilium'. These experiments are described below.

Dutch light experiment

This experiment was chiefly concerned with matters of technique likely to arise in the layout of future experiments on Dutch lights, particularly where, as in orientation experiments, relatively short lengths of frame are used. The points investigated were the extent of end-effects in relatively short frames, and the possibility that the conditions in the centre of a frame might depend on the length of the frame. The experiment was divided into two, one half with single-span and the other half with double-span frames. Frames having lengths of 3, 6 and 9 lights were set up, each with separate end-boards. Spacing was introduced as a further variable, and three spacings, giving 35, 24 and 15 lettuce per light were used. The layout was in the form of a Latin square for the frame lengths with the spacing treatments applied to the rows. There were four replications for each type of span. The lettuce were cut as they became marketable, and the total weight at each cutting date for each light was recorded. The soil was not in a wholly satisfactory condition at that time for growing lettuce under Dutch lights and hence useful recommendations cannot be made from the results of the various spacings. However, the results showed that the end effects were restricted to a single light at the end of each frame and that the centres of each length of frame showed no significant differences in total weight of lettuce cut, or in average cutting date. It appears, therefore, that in experiments with lettuce grown under Dutch lights, the use of short lengths of frame to simulate conditions under longer lengths is justified, provided that the end lights are considered as guard lights. The data from this experiment also showed that the use of a single light as a plot, if practicable from the experimental viewpoint, would make the most efficient use of the frames available.

'Krilium' experiment

An experiment was started to discover the effect of the polyelectrolyte resin soil-conditioner 'Krilium',* both directly on the soil, and as reflected in the yield of four market-garden crops. The treatments in the experiment comprised four concentrations of 'Krilium', zero, 0.025, 0.05, and 0.1 per cent. by weight of the soil with which it was incorporated; two depths of incorporation were used, three and six inches, the soil conditioner being applied to a dry surface of the soil, and incorporated with a rotavator. The control plots which were intended to represent the best local practice, were not rotavated. The plots with incorporation to three inches were duplicated, one set receiving extra water during dry spells, and the other receiving no extra water. The layout was of the split-plot type, the main plot treatments being incorporation to three inches—watered and unwatered—and incorporation to six inches; each main plot was split into four sub-plots, each ten feet square, receiving the four concentrations. There were five blocks, making 60 plots in all. The two-year rotation chosen was peas, spring onions, lettuce and carrots.

*The compound, kindly supplied by Monsanto Chemicals Ltd., was the sodium salt of hydrolysed polyacrylonitrile, C.R.D. 189, Monsanto's Formulation 9.

The experiment is intended to run for a number of years, and a duplicate experiment containing the other phase of the rotation will be started in 1953. For these reasons, no detailed results of the first crop, peas, are presented this year. Since the time of application of the conditioner, eye differences have been apparent in the surface texture of the soil, which were particularly noticeable in periods of drying-out after rain. The control plots were lighter in colour and smoother (more 'panned') in texture, than the treated plots. There were also differences in the moisture content of the plots after heavy rain. The heaviest application of the conditioner resulted in a considerably increased yield of peas, although the largest increase in yield came from the watering treatment. It is possible that some of the apparent effect of the conditioner was due to the rotavation at the time of incorporation, although differences in response to the various concentrations show that it could not account for the whole difference. The second phase of the experiment will contain additional rotavated control plots, so that this point can be elucidated. The origin of the increase in yield due to the conditioner in the unwatered plots appeared to be in the increased number of pods per plant rather than in any increases in stand of plants or weight of pods; there was an indication that watering increased the weight per pod.

Polygenic variation

In the Station's 1951 report, mention was made of work in progress on the practical and theoretical aspects of the analysis of polygenic variation. On the practical side, two further varieties of French Bean, Continuity and an inbred line of Pershore Favourite, kindly supplied by Mr. L. G. Wigan, have been added to the two varieties originally chosen, and first crosses have been made during the year. On the theoretical side, two papers, entitled 'Some genotypic frequencies and variance components occurring in biometrical genetics' and 'Statistical models in biometrical genetics' have been accepted for publication in *Heredity*.

Work for other bodies

The writer has advised the Glasshouse, Flowers, and Protected Cropping Working Parties of the Agricultural Improvement Council Experimental Horticulture Committee on the design of certain experiments being done, or about to be done, on the N.A.A.S. Experimental Horticulture Stations.

Analyses have been completed and reports prepared on two Dutch light experiments carried out by the N.A.A.S. Experimental Horticulture Stations at Luddington (Warwickshire) and Stockbridge House (Yorkshire). Other bodies to which help has been given with the design or analysis of experiments, or both, include the N.A.A.S. Experimental Horticulture Stations at Efford (Hampshire), Fairfield (Lancashire), and Rosewarne (Cornwall), the Kirton (Lincolnshire), and Terrington (Norfolk) Experimental Husbandry Farms of the N.A.A.S., the South-Eastern and Eastern Provinces of the N.A.A.S., the Fruit and Vegetable Preservation Research Station, Campden (Gloucestershire), the Marketing Division of the Ministry of Agriculture and Fisheries, the Ditton Laboratory of the D.S.I.R., the School of Agriculture, Nottingham University, and the Wattle Research Institute, University of Natal, South Africa.

THE WEATHER DURING 1952

RECORDS OF THE N.V.R.S. CROP WEATHER STATION

By ANN PURDY, B. G. HUNT and E. J. WINTER

In order to present a complete picture of the winter season, the following notes and graphs also include readings for October, November and December, 1951.

During the winter of 1951-52, ground frosts were recorded on 98 nights, and air frosts on 57 nights. The first air frost was on 23rd October and the last on 25th April. The most severe air frost was on 27th January, when there were 15 degrees of frost.

In the winter 1952-53, the first ground frost occurred on 8th September, and the first air frost on 10th October.

Fig. 1 shows mean temperatures above and below ground. The highest maximum air temperature, 88°F., was recorded on 1st July. On that day, the soil temperature at four inches deep was 80° F. On 25th November, 1952, the soil was frozen to a depth of four inches, the deepest penetration of frost since the records were begun on 1st October, 1950.

Fig. 2 shows average daily rainfall, sunshine and run-of-wind for each month in the period under review. From April to August there was a daily average of 5.7 hours of sunshine ; in August, however, the daily average was only 39 per cent. of the maximum possible amount. Fig. 3 shows the number of wet days during each month. Rain fell on about half the days from March to June, while about two-thirds of September and October were wet. Fig. 4 shows the monthly distribution of precipitation. The total rainfall during 1952 was 24.97 inches. Although this was about average, the rainfall from February to June was below normal, and there was a severe drought in July ; this was followed by abnormally heavy rainfall in August. On 4th August 1.66 inches of rain fell in 24 hours. February was unusually dry, but at that time of year, the soil is normally at field capacity, and lack of rain is not serious.

The year may be described as having had good growing weather in spring, followed by more difficult conditions in summer. Although the September rainfall was low, it was spread over two-thirds of the days.

November 1951 was unusually warm, but in November 1952 temperatures above and below ground were very low, and that month will long be remembered for the fogs which were general throughout the country.

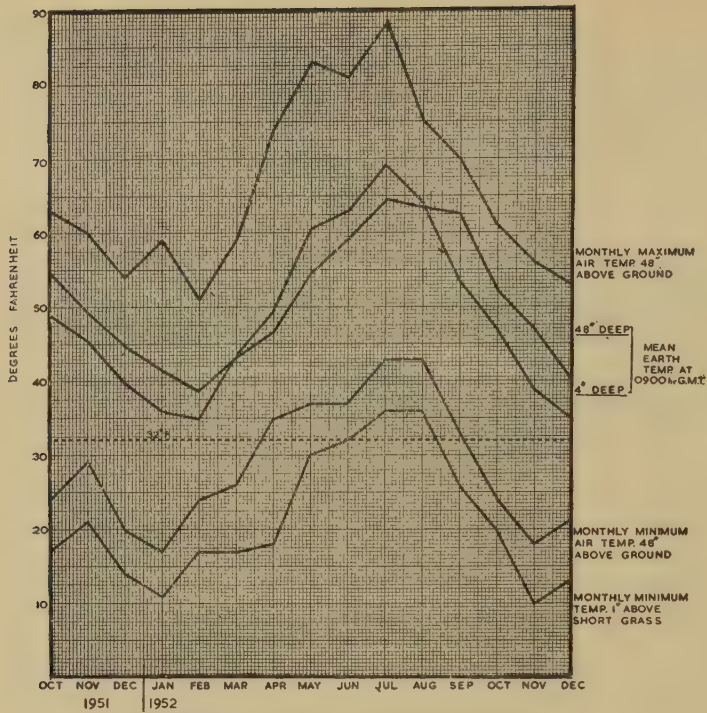


FIG. 1 TEMPERATURES AT N.V.R.S. CROP WEATHER STATION

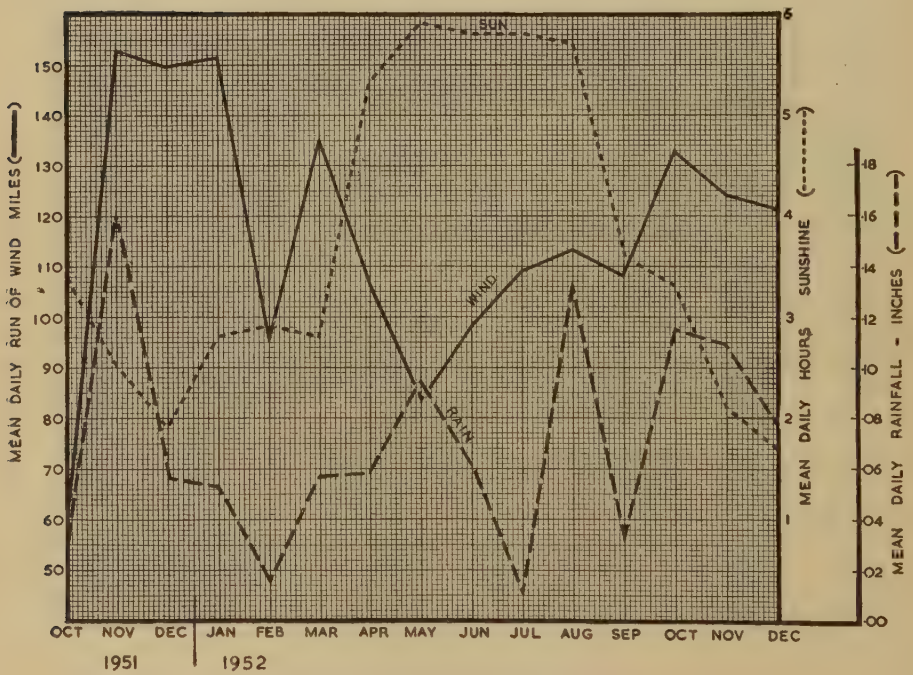


FIG. 2 MEAN DAILY SUNSHINE, RAINFALL AND RUN OF WIND

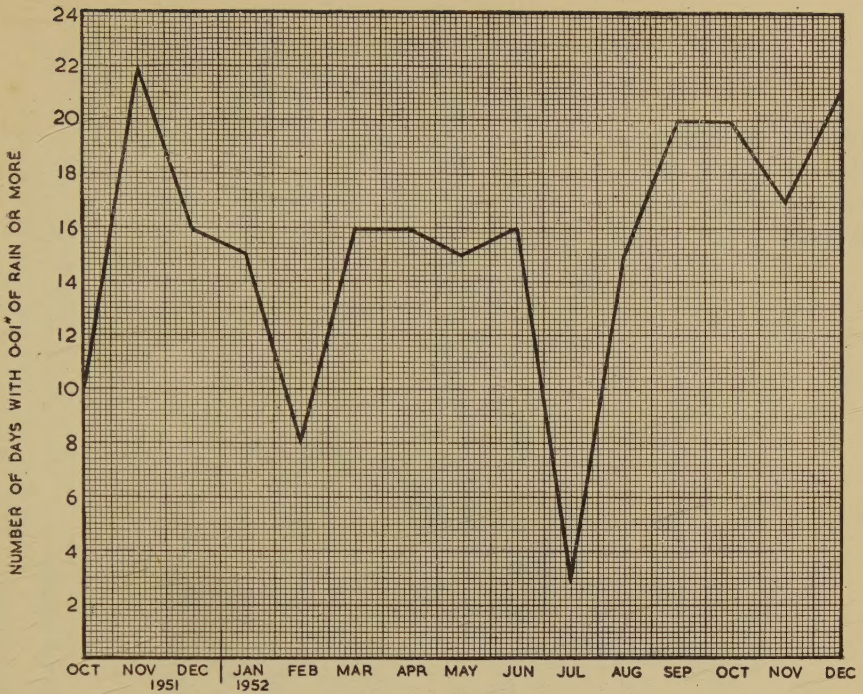


FIG.3 NUMBER OF WET DAYS PER MONTH

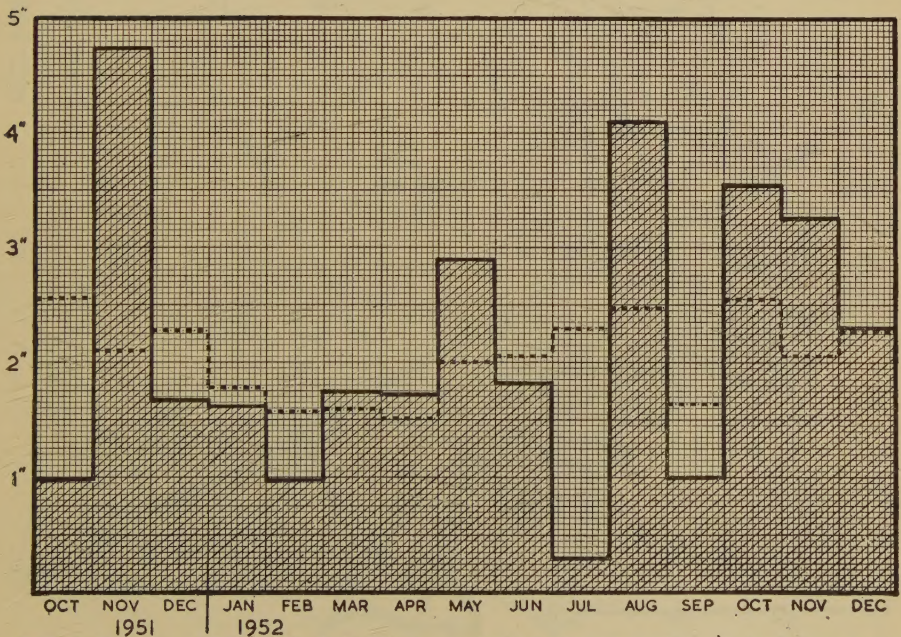
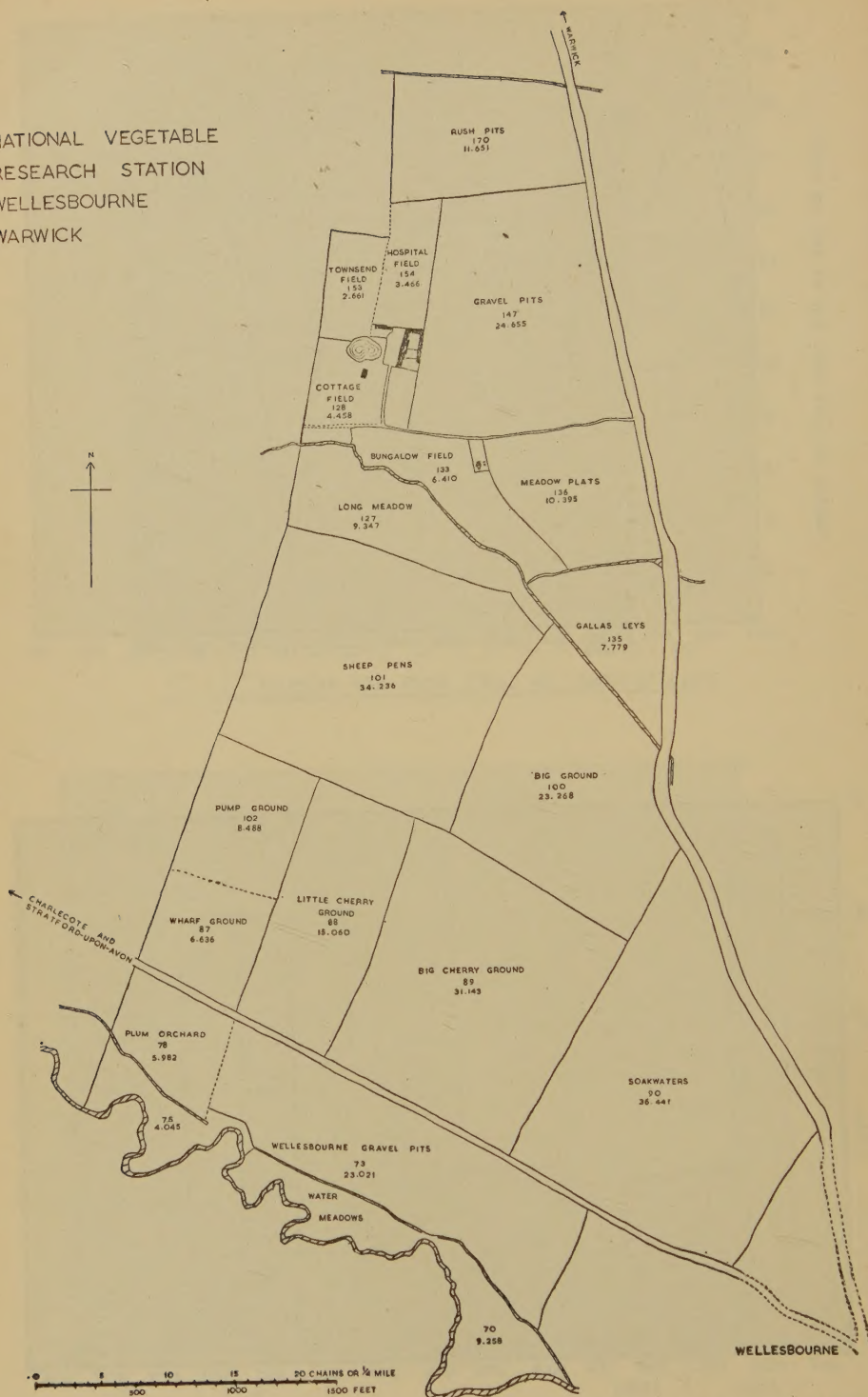


FIG.4 TOTAL MONTHLY RAINFALL

Dotted line shows long-term average at
Shottery Hall, 6 miles from Wellesbourne.

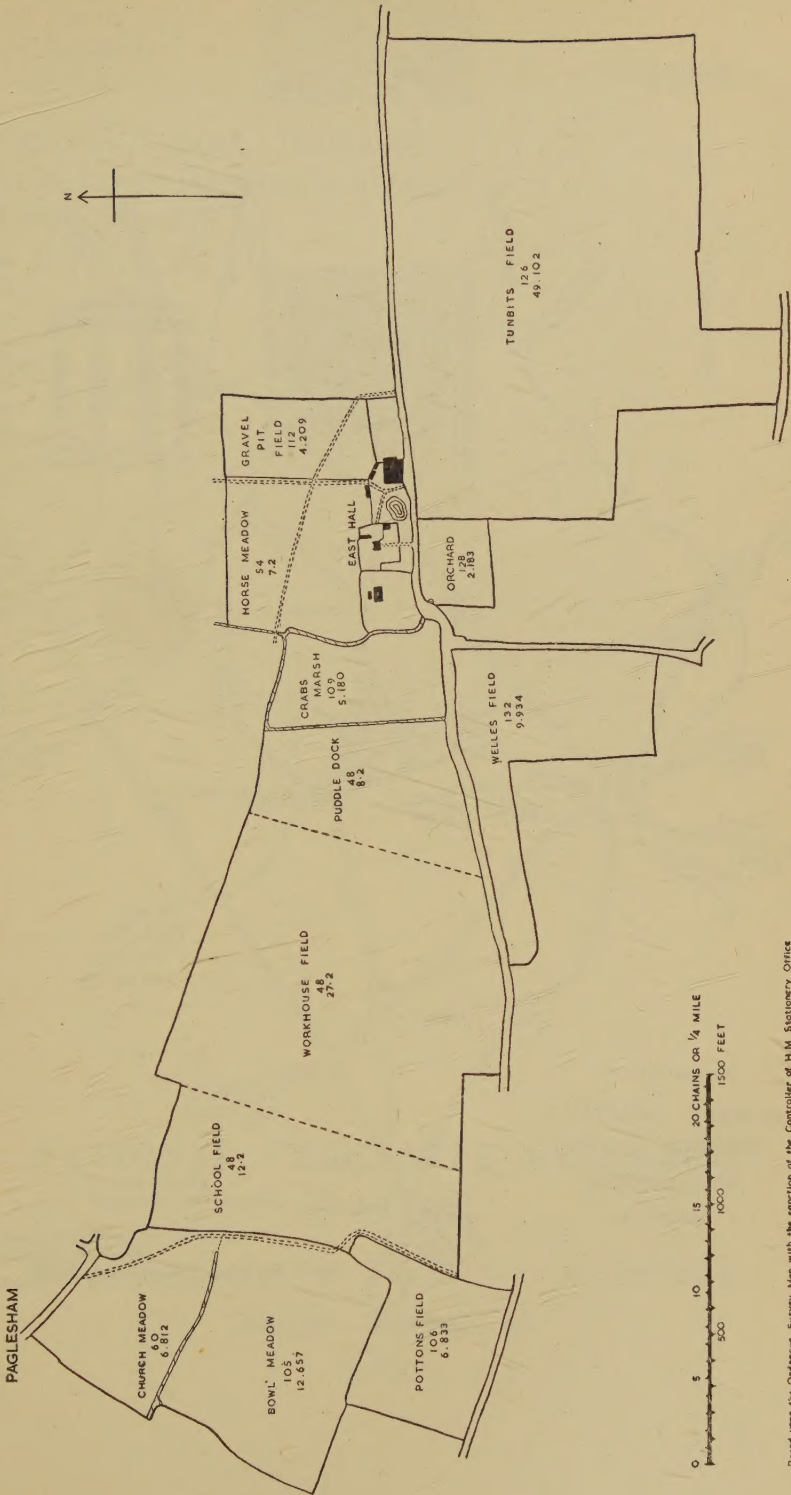
NATIONAL VEGETABLE
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